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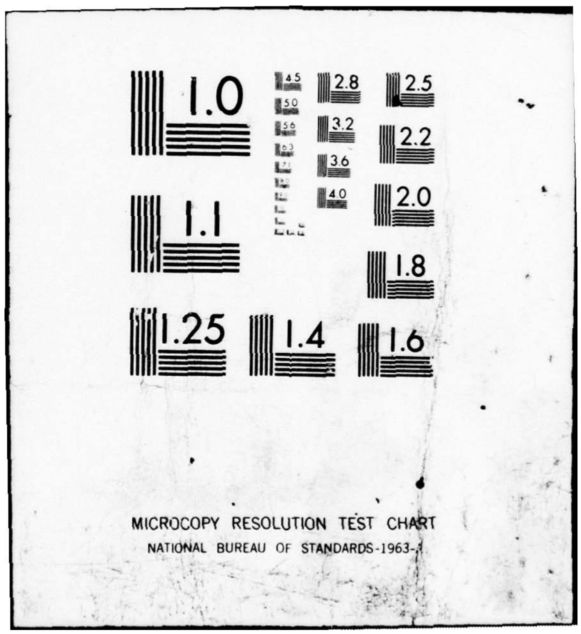
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SYSTEMS APPROACH TO LIFE-CYCLE DESIGN OF PAVEMENTS
VOLUME II: LIFE2 SYSTEM DOCUMENTATION

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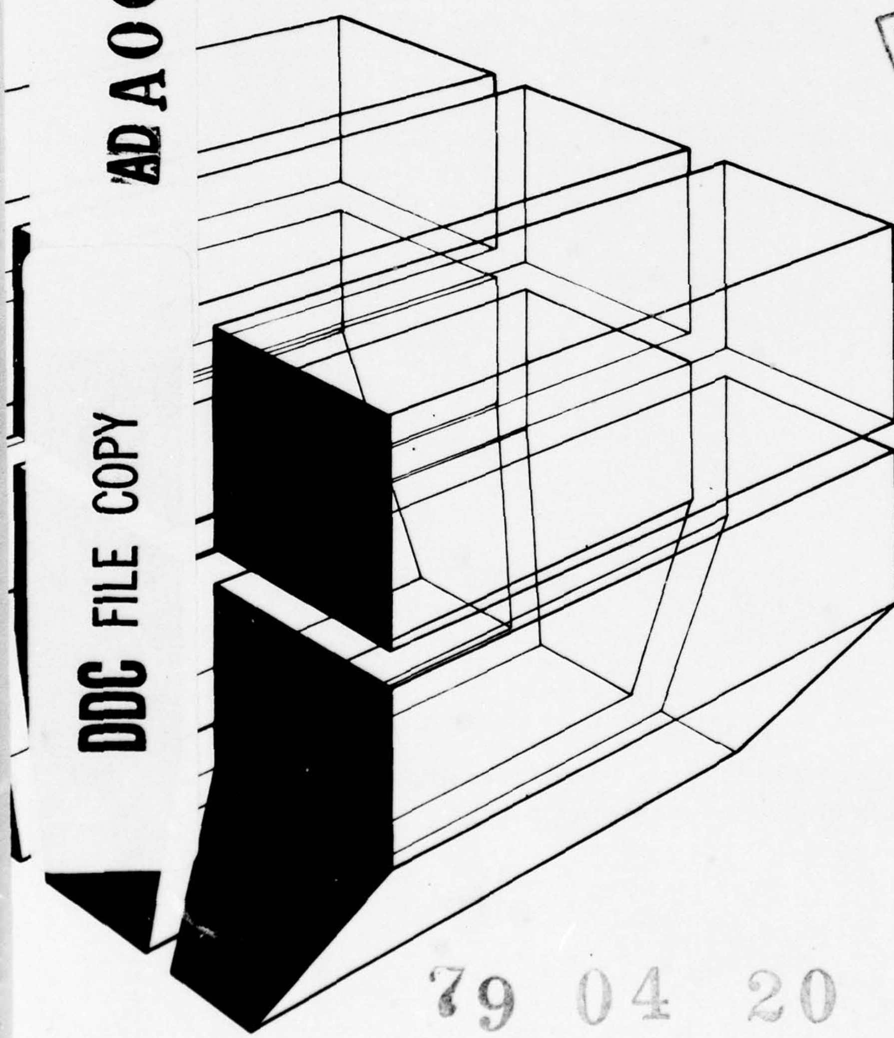

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This report is the second of a three volume final report which documents an automated system, LIFE2, for analyzing pavement designs and maintenance and repair strategies based on life-cycle costs. LIFE2 models existing Corps of Engineers criteria for designing both rigid and flexible pavements for airfields, roads, and streets. The program also includes analytical procedures for evaluating earthwork, drainage, and — CONT'

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frost protection requirements in addition to maintenance costs. The resulting combinations of design schemes and maintenance strategies are ranked by total cost over the design life of the pavement.

Volume I is the LIFE2 User Manual, Volume II is the LIFE2 System Documentation, and Volume III is the LIFE2 Program Listing.

FOREWORD

This work was conducted as part of the RDT&E Army Program 6.37.34A, Project 4A763734DT08, "Military Construction Systems Development," Task 01, "Military Airfield Facilities," Work Unit 001, "Systems Approach to Life-Cycle Design of Pavements." The technical monitor was Mr. E. Dudka, DAEN-MPE-T, Advanced Technology Branch, Engineering Division, Military Construction, Office of the Chief of Engineers.

The work was conducted by the Engineering and Materials Division (EM), U.S. Army Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Mr. E. S. Lindow. The LIFE1 computer program was developed by Drs. P. F. McManus and E. L. Marvin. Mr. J. J. Brown was responsible for programming and maintenance of LIFE2.

Dr. G. R. Williamson is Chief of EM. COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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SYSTEMS APPROACH TO LIFE-CYCLE
DESIGN OF PAVEMENTS
VOLUME II--LIFE2 SYSTEM DOCUMENTATION

1 INTRODUCTION

Background

LIFE2 is a digital computer program devised as an engineering aid for pavement designers and managers. The program includes analytical procedures for designing both rigid and flexible pavements and for evaluating various maintenance and repair strategies. The resulting combinations of design schemes and maintenance strategies provide the pavement manager with life-cycle alternatives.

In the early 1970s, CERL began developing an automated system for designing airfield pavements based on life-cycle cost comparisons. The first iteration of this computer system, designated LIFE1, included procedures for (1) performing rigid and flexible pavement and overlay designs for airfields, (2) analyzing user costs and maintenance and repair (M&R) costs on a macroscale, and (3) combining design schemes and maintenance strategies into life-cycle cost rankings.[1,2]

Subsequently, the system was expanded to include life-cycle design of pavements for roads, streets, and other surfaced areas. This second iteration, LIFE2,[3] also included procedures for considering maintenance costs on the basis of individual M&R activities, thereby making the system more responsive and efficient in terms of data available to the user. Frost protection design criteria were computerized and incorporated into LIFE2. In addition, since earthwork and subsurface drainage costs vary with the pavement thickness design selected, automated procedures for considering these costs were included as optional analyses for the user.

LIFE2 was field-tested in 1976 at the Corps of Engineers' Fort Worth District Office. Based on results of the field test and recent

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1 E. Marvin and P. McManus, *Life Cycle Analysis of an Airfield Pavement Facility*, Unpublished Report (Construction Engineering Research Laboratory [CERL], 1972).

2 J. Wilmer, et al., *User Manual for LIFE1 Computer Program*, Technical Report S-28/AD774849 (CERL, January 1974).

3 E. Lindow, et al., *LIFE2 User's Manual*, Technical Report C-59/ADA023186 (CERL, January 1976).

updating of the pavement design criteria, minor modifications were made to the LIFE2 system. LIFE2 is now an implementable tool which can help pavement managers optimize expenditures by basing decisions on life-cycle costs rather than solely on the least first cost.

Objective

The objective of this research is to develop and validate computer-aided procedures to perform life-cycle design analyses of pavements; these procedures will help the user select the most economical pavement contruction or repair that will meet the pavement facilities' objectives based on total cost over the life span of the facility.

Approach

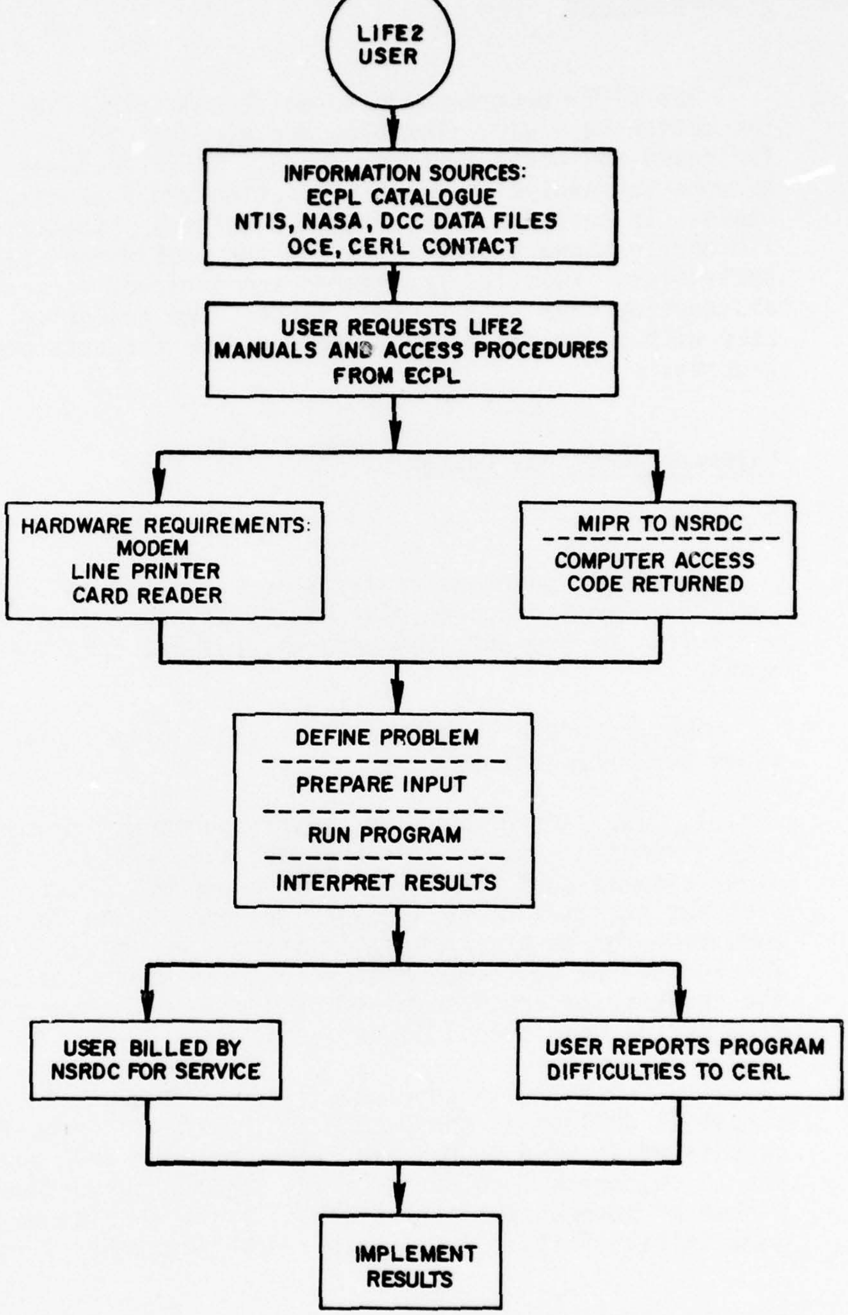
LIFE2 is based on Corps of Engineers' pavement design methods and criteria. Certain deviations and additions were necessary to amalgamate the manual procedures into an automated system; however, for identical conditions and design lives, pavement structural thickness designs in LIFE2 will be identical to those of the manual procedure.

This report provides the LIFE2 system documentation. Chapter 2 is a general overview of the design methods and analytical procedures. Chapter 3 describes the LIFE2 software, and Chapter 4 presents conclusions. The appendices contain the detailed documentation of each program unit. An alphabetical index of the routines facilitates locating individual routines in the appendices.

Mode of Technology Transfer

The LIFE2 system was developed principally as an engineering tool for use by Corps of Engineers District Office personnel. Access to the LIFE2 program for Corps of Engineers personnel will be through the Corps' Engineering Computer Program Library (ECPL).* Figure 1 illustrates the procedure to be used. For other users, the program and relevant documentation are available from National Technical Information Service.

* ECPL is located at the U.S. Army Waterways Experiment Station, Vicksburg, MS.



KEY:

ECPL-CORPS ENGINEERING COMPUTER PROGRAM LIBRARY
MIPR-MILITARY INTERDEPARTMENTAL PURCHASE REQUEST
NSRDC-NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, BETHESDA, MD.
NTIS-NATIONAL TECHNICAL INFORMATION SERVICE

Figure 1. Flowchart of LIFE2 access procedure.

2 METHODOLOGY

The LIFE2 program models analytical procedures adopted by the Corps for designing rigid, flexible, and overlay pavements for airfields and for roads and other surfaced areas. LIFE2 includes the Corps' procedures for analyzing frost protection and subsurface drainage requirements. In addition, the program simulates procedures for analyzing preliminary earthwork quantities and for considering maintenance and repair activities. Finally, procedures are included for computing costs and discounting them to a present worth. The following sections provide the user with a general understanding of the concepts employed in these procedures.

Pavement Thickness Design

Rigid Pavement

The rigid pavement analysis incorporated in LIFE2 designs a plain portland cement concrete slab having an underlying base course, if applicable. At present, the program does not consider reinforced pavements.

The procedure for designing rigid airfield pavements follows the steps described below.

1. Two sets of maximum tensile bending stresses are calculated for each aircraft: one assumes that the slab rests on the subgrade, and the other assumes that the slab rests on asphalt (i.e., rigid overlay). Each set consists of 10 stresses produced by analyzing an edge-loading condition for 10 thicknesses of slab. The analysis uses a computerized version of the Westergaard elastic-plate-on-a-liquid-subgrade theory.[4] The thicknesses are determined by dividing a range of thicknesses specified by the user into 10 equal parts.

2. The ratio of concrete flexural strength to the maximum edge stress is defined as the Design Factor (DF). Using the edge stresses calculated in step 1, DFs are determined for each aircraft at each of the 10 thickness levels. From the fatigue curve shown in Figure 2, the number of coverages of the aircraft being considered (which would produce initial failure in a plain concrete pavement) is determined for

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4 W. C. Kreger, *Computerized Aircraft Ground Flotation Analysis--Edge-Loaded Rigid Pavement*, Report ERR-FW-572 (General Dynamics Corporation, 1967).

each slab thickness. This produces an array of coverages-to-failure vs. slab thickness for each aircraft.

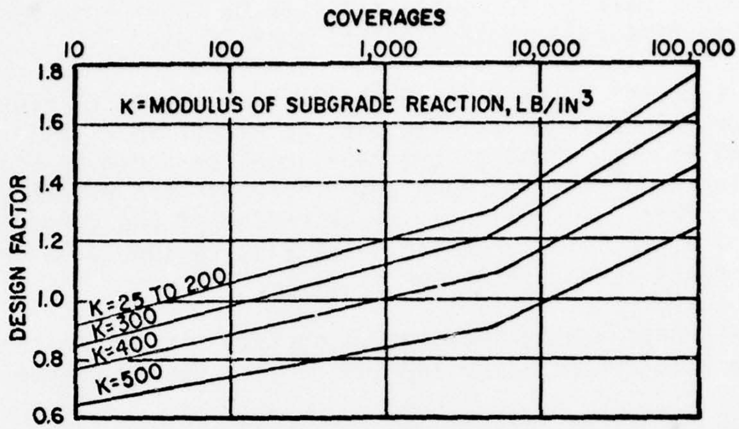

Figure 2. Coverages-to-failure curve. (From G. M. Hammitt, et al., *Multiple-Wheel Heavy Gear Load Pavement Tests: Volume IV*, Technical Report No. 70-113 (Air Force Weapons Laboratory, November 1971).

3. Mixed traffic is accounted for by enforcing Miner's rule:

$$\sum_{i=1}^{N} \frac{(\text{actual coverages})_i}{(\text{coverages to failure})} = 1$$

where: i designates a particular aircraft
N is the number of aircraft considered.

The actual coverages for each of the i = 1,N aircraft are derived from estimated traffic volumes. The traffic volumes are summed for the time being considered and then converted to coverages by an empirically determined pass-to-coverage ratio. The mixed traffic coverages to failure are determined by interpolation of the thickness vs. individual coverages-to-failure relationship produced in step 2. This computation can be performed at user-specified times; otherwise, the program divides the design life of the pavement into six periods and performs the computation for each. The ultimate result is a thickness vs. time relationship for the total traffic being considered.

This procedure is an extension of Corps of Engineers' design procedures. If only one aircraft is considered (typically the predominant type), this theory reduces to the Corps criteria.

4. The slab thickness required to provide a serviceable pavement until the first overlay is placed can then be determined by using the thickness vs. time relationship established in step 3.

5. A tradeoff between the slab and base course thicknesses is performed. For various base thicknesses, an effective k (subgrade modulus of reaction) is determined by the relationships shown in Figure 3. The required slab thickness for each base thickness and effective k are then calculated. This calculation is an extension of the Corps method commonly used for preliminary design. The k value should be verified by plate load tests conducted at the site.

6. Thickness constraints resulting from minimum thickness and frost protection criteria are applied to each design scheme.

7. The resulting schemes are evaluated by cost, and one optimal design is retained.

8. The program returns to step 4 and analyzes each overlay strategy.

The design of rigid pavements for roads and streets is slightly different and uses the following procedure.

1. A slab thickness for 5000 coverages is found by using information shown in Figure 4.

2. Design traffic is specified by a Design Index ranging from 1 to 10. The Design Index is converted to 18,000-lb (8100-kg) equivalent single-axle loads (ESAL), and this quantity is then equated to coverages.

3. Using Figure 5 and the number of coverages determined in step 2, a percentage of design thickness is found. The slab thickness required for the design traffic is produced by multiplying the thickness for 5000 coverages (step 1) by this percentage.

4. The remainder of the analysis uses steps 5, 6, and 7. For each overlay strategy, the analysis loops back to step 2.

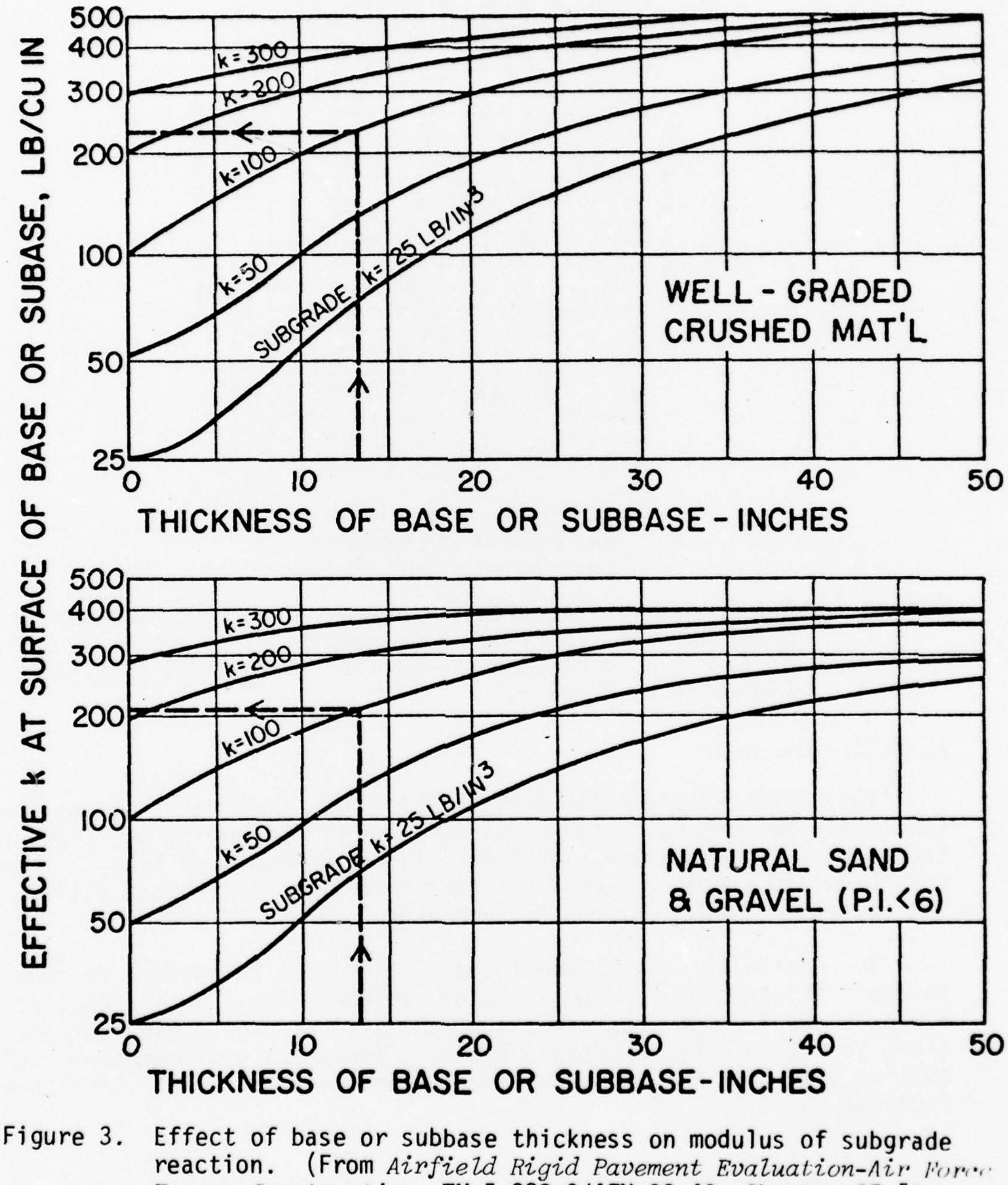

Figure 3. Effect of base or subbase thickness on modulus of subgrade reaction. (From *Airfield Rigid Pavement Evaluation-Air Force Energy Construction*, TM 5-888-9/AFM 88-40, Chapter 37 [Army and Air Force, 1966]).

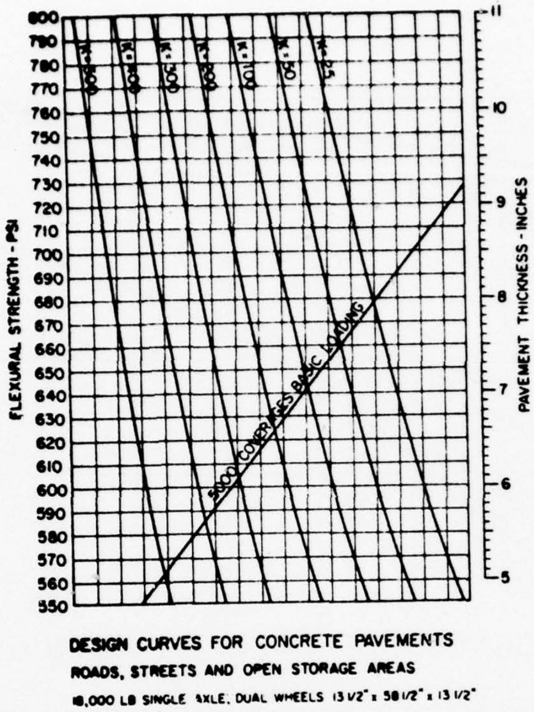

Figure 4. Design curves for concrete pavements. (From *Development of Rigid Pavement Thickness Requirements for Military Roads and Streets* [Technical Report No. 4-18, Ohio River Division Laboratories, 1961]).

Flexible Pavements

The LIFE2 procedure for designing flexible pavements follows the California Bearing Ratio (CBR) design method developed by the Corps of Engineers. The procedure used for airfield pavements is like that used for roads and streets, except that the thickness constraints differ. The following steps outline the procedure:

1. Equivalent single-wheel loads (ESWL) are calculated for 20 pavement thicknesses for each type of vehicle. The ESWL is the load on a single wheel which produces a maximum deflection on a pavement equivalent to the deflection beneath the multiple-wheel configuration. LIFE2 obtains this ESWL vs. thickness array from the Vehicle Data Bank (see Appendix J).

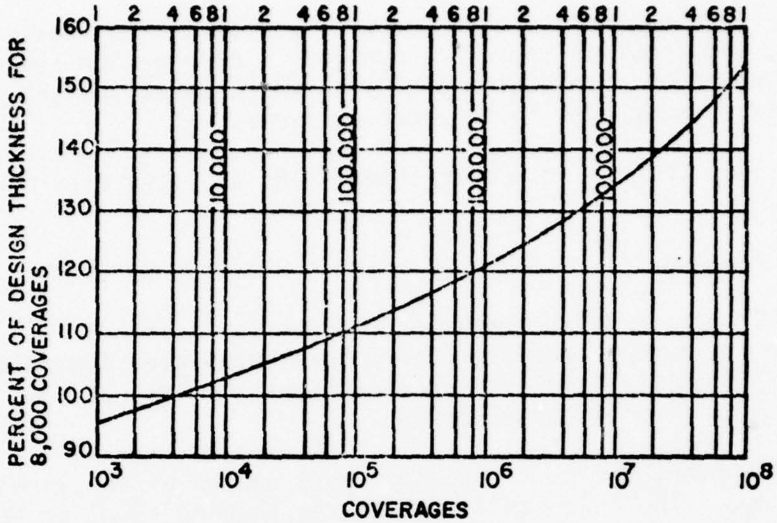

Figure 5. Coverages vs. rigid pavement thickness. (From *Development of Rigid Pavement Thickness Requirements for Military Roads and Streets*, Technical Report No. 4-18 [Ohio River Division Laboratories, 1961]).

2. A fatigue curve and a CBR vs. thickness curve are used to derive a thickness vs. coverage-to-failure relationship for each CBR value considered in the design analysis.

3. The effect of mixed traffic is considered as in step 3 of the rigid analysis; a design thickness vs. time curve is obtained for each CBR value being considered.

4. Using a thickness vs. time curve and the time to the first overlay, the required thickness above the subgrade is determined for each pavement layer.

5. The program generates various combinations of layers to satisfy the thickness requirements. Layers are arranged so that CBR values decrease with depth.

6. The total thickness is adjusted according to the effects of a specific climate. (For example, in regions where annual precipitation is less than 15 in. (381 mm), the water table is at least 15 ft (4.5 m) below the pavement surface; subgrade moisture content is predicted to be

less than optimum, the climate is classifeid as DRY, and the required thickness above the subgrade is reduced by 20 percent.)[5]

7. Thickness constraints resulting from minimum layer thickness, density, and frost criteria are applied to each design scheme. The program saves every combination of layers which satisfies the requirements and ranks them by cost in the cost analysis.

8. The program returns to step 4 and analyzes each overlay strategy.

Overlay Pavement

LIFE2 can consider four types of overlay designs: (1) rigid overlay over rigid construction, (2) rigid overlay over flexible construction, (3) flexible overlay over rigid construction, and (4) flexible overlay over flexible construction.

Rigid overlay over a rigid pavement can be either partially bonded or unbonded. The user can stipulate the bonding type, or the program can consider both types and select the more economical design. For partial bonding, the overlay thickness is determined by:

$$h_o = \sqrt[1.4]{h_d^{1.4} - Ch^{1.4}} \qquad \text{[Eq 1]}$$

where h_o = rigid overlay thickness in inches

h_d = the required thickness of slab for traffic predicted for the overlay's service life. This thickness is calculated by the procedure used to design rigid pavements

C = coefficient depending on the condition[6] of the existing pavement

C = 1.00 for good condition (i.e., little or no structural cracking in slabs)

C = 0.75 for initial failure (i.e., slabs show initial cracking due to loading, but little or no multiple cracking)

---

5 *Airfield Flexible Pavement - Air Force,* TM5-824-2 (Department of the Army, February 1969).

6 *Rigid Pavements for Airfields Other Than Army,* TM-5-824-3 (Department of the Army, 7 December 1970).

C = 0.50 for shattered slabs (i.e., a larger number of slabs shows multiple cracking, but most are intact or contain only single cracks)

C = 0.35 for complete failure (i.e., the majority of slabs show multiple cracking)

h = the existing rigid pavement thickness in inches.

For an unbonded condition, the formula is:

$$h_o = \sqrt{h_d^2 - Ch^2} \qquad \text{[Eq 2]}$$

To evaluate a rigid overlay on a flexible pavement, the thickness is determined by the procedure used to evaluate new rigid pavements; however, the analysis uses concrete stresses, assuming an asphalt foundation (see step 1 of the rigid pavement procedure) rather than a soil foundation.

The thickness of flexible overlay on an existing rigid pavement is determined by:

$$t = 2.5(Fh_d - Ch) \qquad \text{[Eq 3]}$$

where t = flexible overlay thickness in inches

F = a transformation factor which specifies failure condition for thickness of new rigid pavement; h_d is the required thickness for initial failure at the end of the appropriate service life. The factor, F, transforms this thickness to that required for complete failure at the end of the service life.[7]

h_d = the required equivalent slab thickness for predicted traffic[8]

C = coefficient depending on the condition of the existing pavement

C = 1.0 for good condition and for initial failure

C = 0.75 for shattered slabs

h = the existing rigid pavement thickness in inches.

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[7] *Rigid Pavements for Airfields Other Than Army*, TM-5-824-3 (Department of the Army, 7 December 1970).

[8] *Rigid Pavements for Airfields Other Than Army.*

To evaluate a flexible overlay on a flexible pavement, the thickness is computed by using the CBR design method employed for evaluating original flexible pavements.

Frost Analysis

The frost analysis procedure[9] supplies criteria for determining the total pavement depth required for frost protection. This depth constraint is determined by using three design methods: (1) complete frost protection, (2) limited subgrade frost penetration, and (3) reduced subgrade strength.

The complete frost protection method is used only when the subgrade soil is classified as an F3 or F4 frost group and when moisture conditions are considered to be extremely variable. This method provides a sufficient thickness of nonfrost-susceptible base, which protects underlying frost-susceptible soils from freezing, thereby eliminating surface deformation by frost action.

The usual method for controlling surface deformation caused by frost heave is the limited subgrade frost penetration design. This method attempts to contain deformations to small, acceptable values, rather than eliminating them completely. When this method is used, both rigid and flexible designs have a sufficient thickness of base material between the frost-susceptible subgrade and the pavement to prevent excessive heave and surface cracking caused by frost penetration.

The reduced subgrade strength method provides for an allowable reduction in subgrade strength during thawing periods. This method usually permits less thickness of pavement and base than the other designs; however, this design can be employed only when objectionable differential heave or pavement cracking will not result.

When more than one of these methods is applicable, the one providing the most economical design is used. It should be noted that in all cases, the bottom 4 in. (102 mm) of nonfrost-susceptible material are designed as a filter. This filter prevents infiltration of the base by subgrade soil, but is not a drainage course per se.

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9 *Evaluation for Frost Conditions*, TM-5-818-3 (Department of the Army, 20 December 1966).

Drainage Analysis

The drainage analysis provided by LIFE2 evaluates only subsurface drainage facilities. Although costs of surface drainage features are a consideration in the overall construction project, they can generally be assumed to be equal when alternative pavement design schemes are compared. Subsurface drainage, however, is a variable, since not all design schemes require underdrains.

The subsurface drainage analysis performed in LIFE2 applies Corps of Engineers criteria,[10-13] as illustrated in Figure 6.

The drainage analysis is included in LIFE2 to improve cost comparison precision between alternative pavement designs. Although this analysis applies accepted design criteria, it is not intended as a final subsurface drainage decision. Engineering judgment should be applied to account for site-unique conditions.

The analysis first determines whether frost penetration or ground water depth will necessitate use of underdrains. In addition, it checks whether the user has specified that underdrains are required for surface flooding, a sag vertical curve, or underground seepage. If underdrains are unnecessary, the analysis is terminated, and this conclusion is printed in the program output.

If underdrains are required, the greatest depth required by frost, ground water, or user criteria is determined. Next, the pipe spacing is determined, with pipes assumed to be at both edges of the pavement. If the quantity of water exceeds the pipe's capacity, underdrains are placed at the pavement section's quarter points. The required pipe diameter is calculated, the construction quantities and costs are determined, and a cost per lineal foot of pipe is calculated. A cost estimate is then derived for laterals and outlets, based on user input and cost per lineal foot. Finally, the total subsurface drainage cost and pertinent underdrain geometry are returned to the main program and become a part of the output.

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10 *Drainage and Erosion Control--Structures for Airfields and Heliports*, TM-5-820-3 (Department of the Army, 14 August 1964).

11 *Drainage and Erosion Control--Subsurface Facilities for Airfields* (Draft), TM-5-820-2 (Department of the Army, 1974).

12 *Drainage and Erosion Control--Surface Drainage Facilities for Airfields and Heliports*, TM-5-820-1 (Department of the Army, 31 August 1965).

13 *Drainage for Areas Other Than Airfields*, TM-5-820-4 (Department of the Army, 15 July 1965).

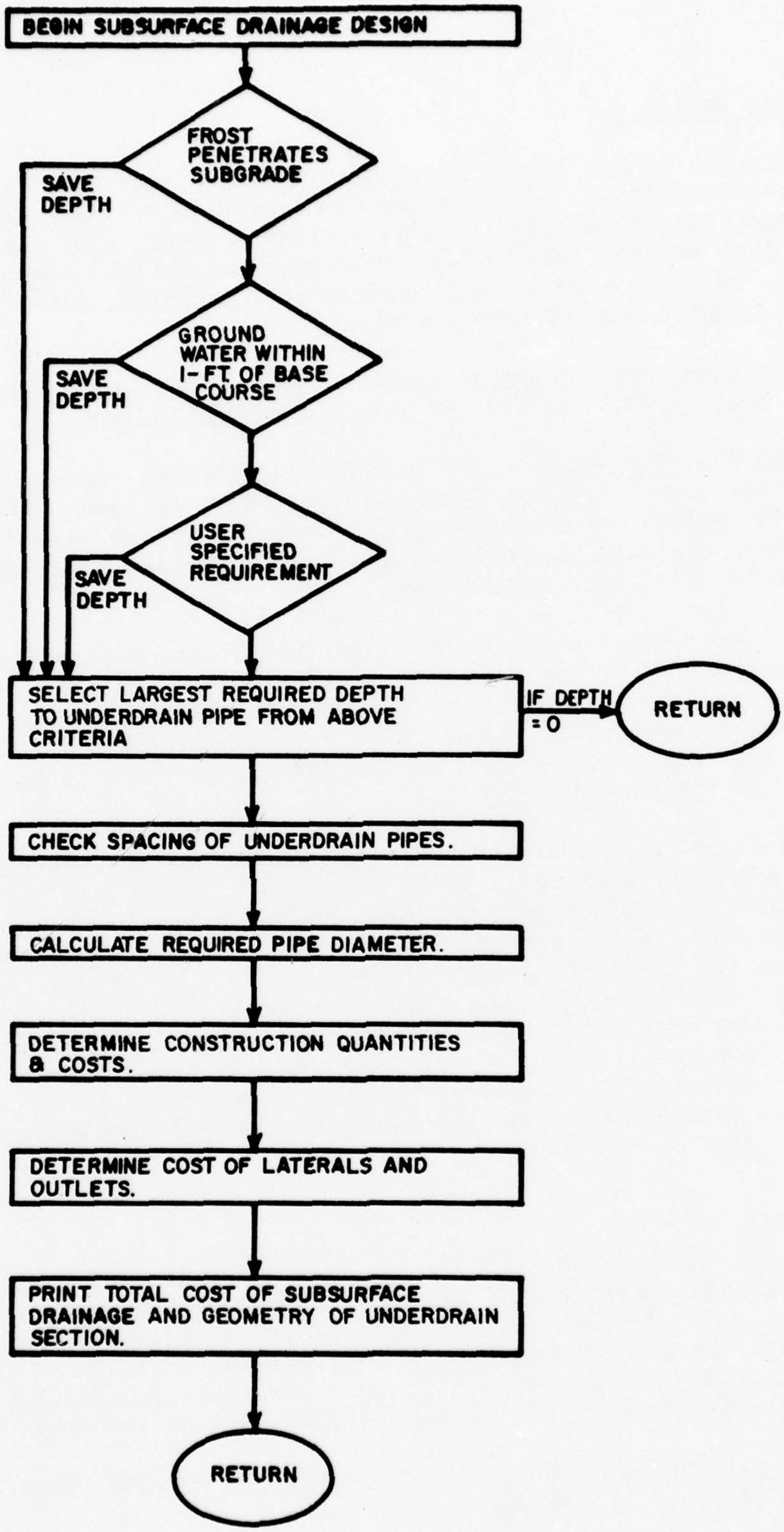


Figure 6. Block diagram of drainage analysis.

Earthwork Analysis

LIFE2 provides a procedure for estimating the quantity and cost of earthwork construction. This earthwork analysis is aimed at developing a cost variable which is directly dependent on the pavement thickness design. This procedure does not provide earthwork computations for the total construction project; more detailed computerized procedures can be used to develop a comprehensive computation of earthwork quantities.[14]

Earthwork analysis uses the following procedure:

1. The end points (TL)* of the survey base line are established by their coordinates (see Figure 7).

2. The site's original topography (TD) is established by cross-section elevations along the base line (50 cross sections and 40 elevations per cross section are allowed).

3. The pavement's center line is established by the coordinates of the end points and their elevations (PGLENDS). The center line does not have to coincide with the survey base line.

4. The profile of the pavement may have up to 20 changes in the grade (see Figure 8); however, in plan, the pavement is considered to be a tangent section.

5. The user stipulates the desired distance between cross section area computations (RUN). The program computes the end area for each cross section, assuming a pavement thickness of zero (see Figure 9). The cut and fill volume between cross sections is computed and summed.

6. The program revises the cut and fill quantities based on the total pavement thickness for each design considered.

7. As an added refinement in airfield design, the earthwork analysis is capable of accounting for excavation in the approach zone area. The user establishes the limits of each approach zone, and the program extends the earthwork calculations beyond the end of the airfield (see Figure 10).

---

* Abbreviations in parentheses are those used in the program input.

14 M. Wiley, *The Digital Terrain System of Earthwork Computation*, (U.S. Army Corps of Engineers, Kansas City District, 1972).

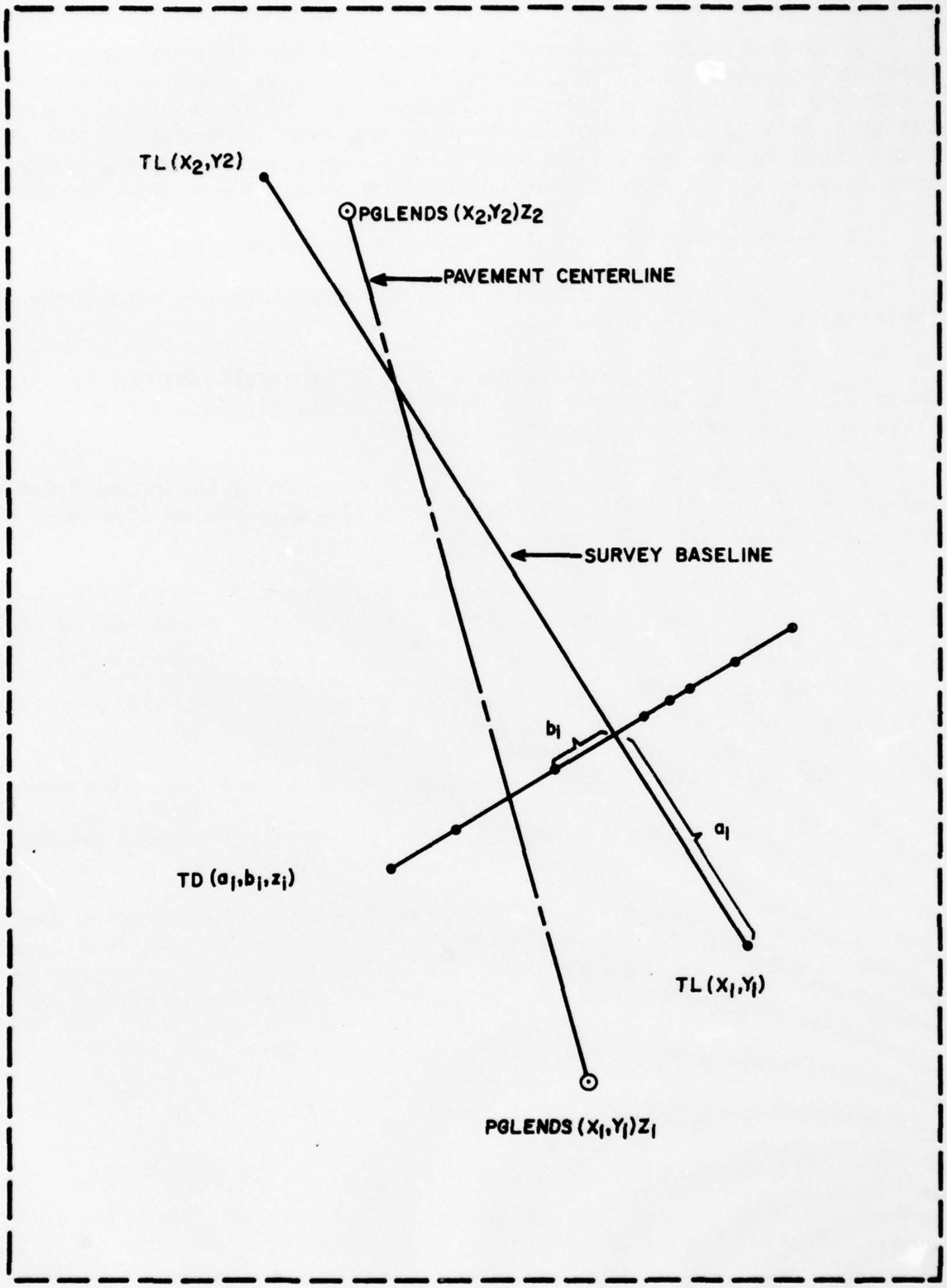


Figure 7. Plan view of earthwork calculations.

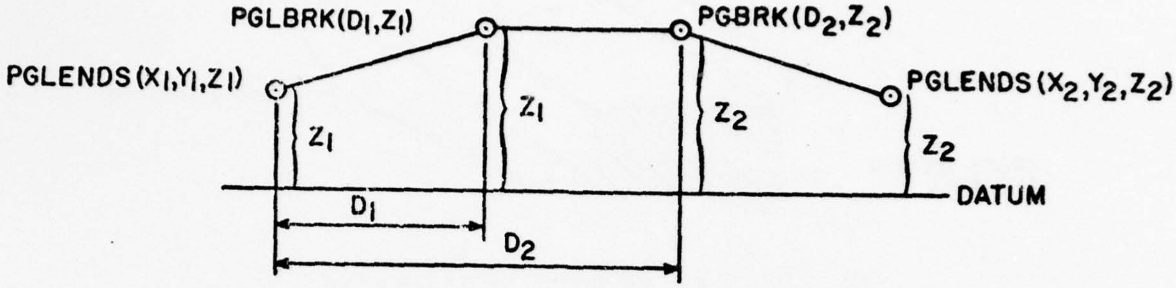


Figure 8. Pavement profile.

8. The earthwork analysis provides an estimated cost and quantity of the cut and fill required for each pavement thickness scheme. At the user's request, the program can supply an earthwork mass diagram (see Figure 11).

Since this analysis does not consider horizontal curves, the method is principally suited to airfield design, but can be applied to designing straight sections of roads and streets. In addition, the user should recognize that the analysis is limited to the area between the pavement edges (i.e., the volume of earthwork in the side slopes is not computed).

Maintenance and Repair Activities

LIFE2 considers M&R activities in terms of costs.* The program uses estimates of yearly or periodic costs for M&R activities and computes the cost of maintaining a serviceable pavement during its design life. These costs are included in the life-cycle cost analysis to optimize selection of a design and/or maintenance strategy.

Specific activities included in the analysis are:

1. Maintaining drains
2. Sealing joints and cracks--rigid pavements
3. Sealing cracks--flexible pavements
4. Cleaning and sweeping--flexible pavements
5. Cleaning and sweeping--rigid pavements
6. Surface treatment--flexible pavements

* For a description of the input and costing procedure for each M&R activity, see Volume I of this report.

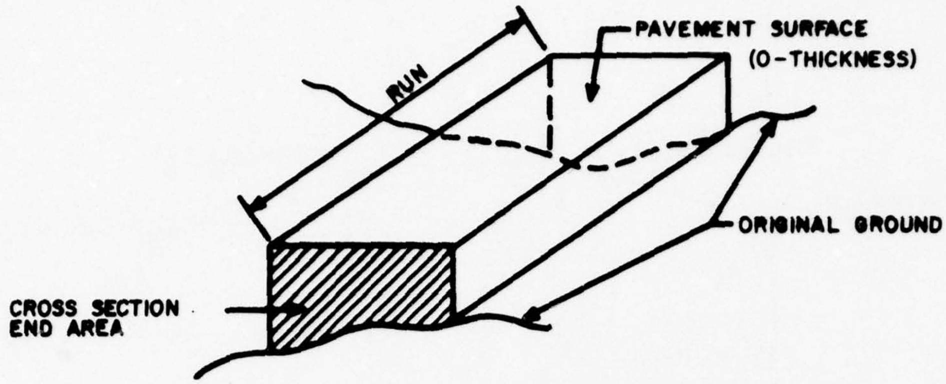


Figure 9. Pavement cross section.

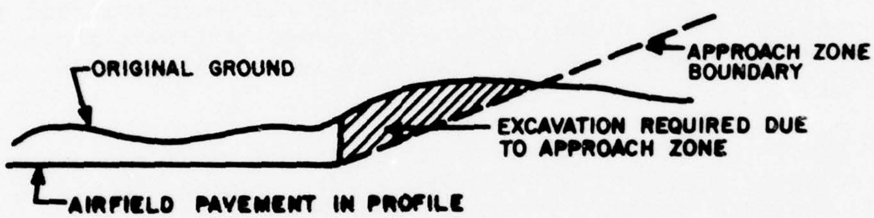


Figure 10. Excavation in the approach zone area.

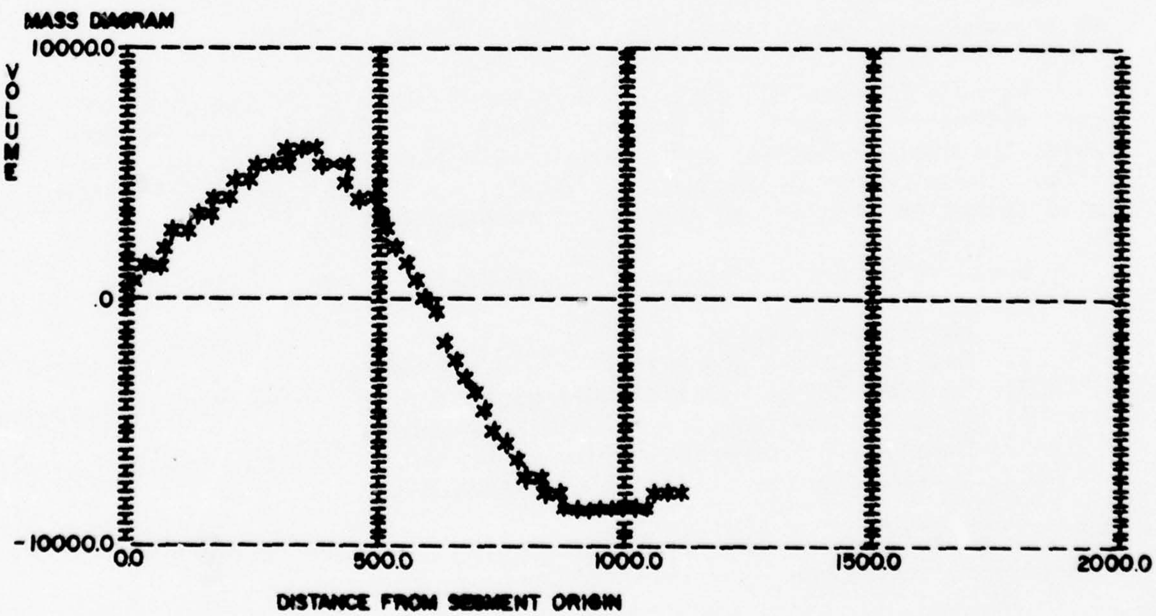


Figure 11. Earthwork mass diagram from LIFE2.

7. Patching--flexible pavements
8. Replacing slabs--rigid pavements
9. Repairing scaling and popouts--rigid pavements.

In addition, four general categories are included for project-specific M&R:

1. Other maintenance--flexible pavements
2. Other maintenance--rigid pavements
3. Other repairs--flexible pavements
4. Other repairs--rigid pavements.

Since a cost estimate for total M&R is sometimes more accessible than an individual cost breakdown, an alternative series of variables is included; these variables can be used to input cumulative M&R cost information in terms of piece-wise linear time functions.

1. Routine maintenance--rigid initial construction
2. Routine maintenance--rigid overlay system
3. Routine maintenance--flexible initial construction
4. Routine maintenance--flexible overlay system.

Cost Analysis

In the cost analysis procedure, costs incurred during the life of the pavement are computed and then compiled to serve as optimization criteria. The incurred costs include pavement construction, subsurface drainage, earthwork, M&R activities, overlays, and user-related expenses. Inclusion of all but pavement construction costs are the option of the user. All costs in each management strategy (i.e., combination of pavement design and associated overlays as required) are discounted to present worth. Output consists of two lists of ranked strategies: one for initial flexible pavement construction, and one for rigid pavement construction. Ranking is by least total discounted cost.

Pavement sections are designed to last from the beginning of construction to the placement of the first overlay. For initial rigid construction, the least cost pavement design is determined. This is either the minimum slab thickness required to support the design traffic, or the required combination of slab and aggregate base course thicknesses, if the latter is approved and results in lower costs. For initial flexible construction, all pavement designs satisfying the Corps of Engineers' criteria are determined and saved. This provides designs which employ minimum layer thicknesses for all possible combinations of the input surface, base, and subbase materials.

Overlay strategies are stipulated by the user. Each strategy indicates the points during the facility's design life when structural pavement overlays are scheduled to be constructed. Up to 10 different overlay strategies may be considered during each program run. For both rigid and flexible initial construction, optimal material type and thickness are determined by least cost for each planned overlay.

Maintenance and user costs are then computed for each overlay strategy. Earthwork and drainage costs are computed for each design scheme. An escalation factor is used to estimate the effect of inflation on all costs; the costs are then relegated to a present worth in the first year of the pavement's design life. Figure 12 illustrates the cost analysis procedures employed.

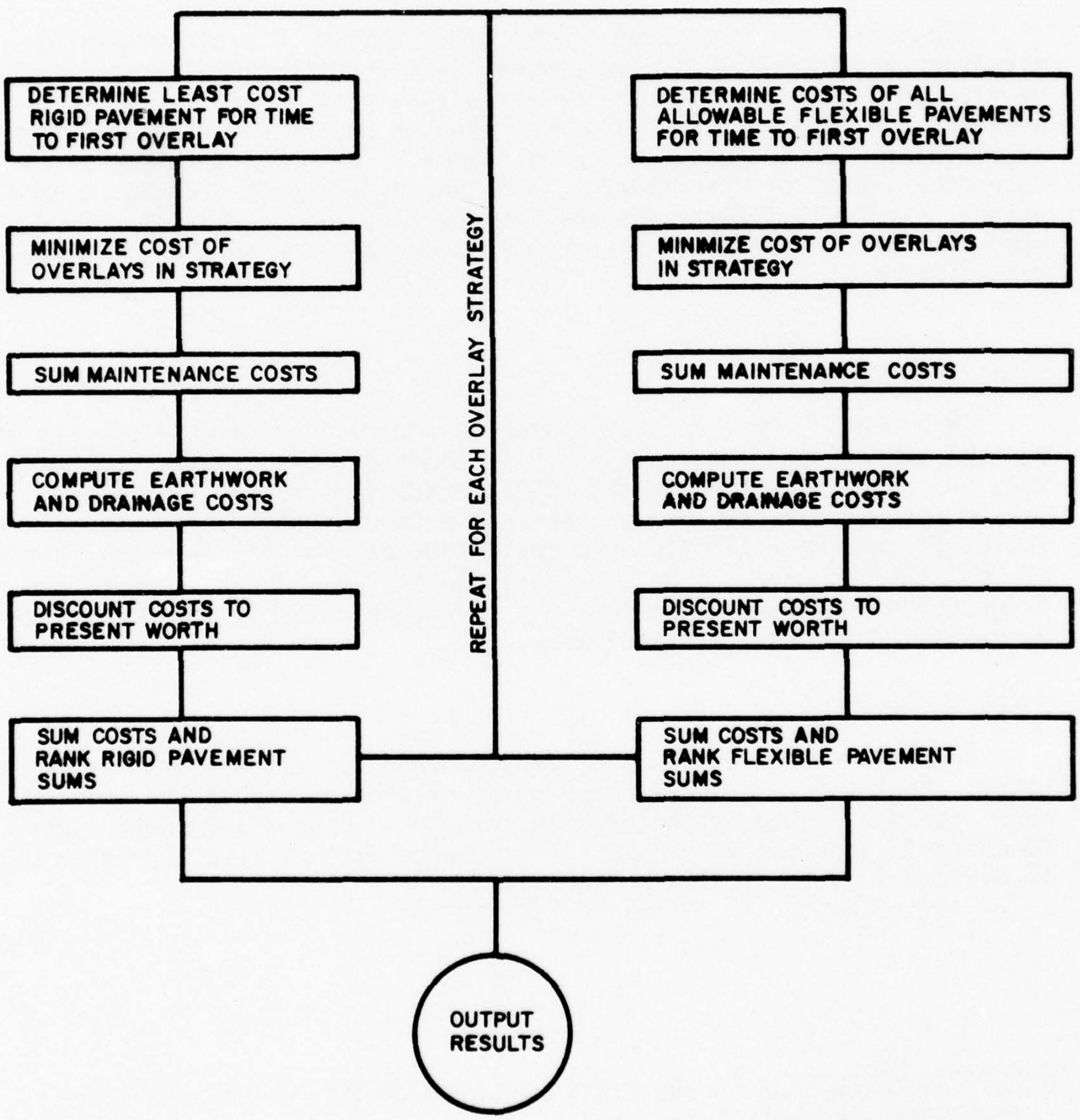


Figure 12. Cost analysis procedure. (Note: The sequence of steps in LIFE2 is different from that shown for ease in automation).

3 SYSTEM DESCRIPTION

The automated system which models the design criteria methodology presented in Chapter 2 is designated as LIFE2. The program is written in FORTRAN Extended* for use on the CDC 6000 series computers. It is currently operating on a CDC 6600 in a remote batch mode.

Program Overlay Structure

Because of the magnitude of the LIFE2 system, a program overlay structure was used in its development. The structure employs a zero overlay, OVERLAY (0,0), as the driver of the program and six primary overlays. OVERLAY (0,0) remains in computer memory while the primary overlays are loaded and unloaded as needed. This process greatly reduces the amount of core storage, and thereby the cost of program operation. Figure 13 illustrates the framework of the overlay structure used in LIFE2. Appendices A through G describe each of the LIFE2 program overlays.

Program Documentation

Each overlay in the LIFE2 system is comprised of a main program and various subroutines and functions. In addition, the LIFE2 system also uses procedures supplied by the FORTRAN Extended program language, called system routines, and an external data bank containing characteristics of vehicular traffic. To facilitate maintenance and modification of the LIFE2 program, as well as to enhance user understanding of the programming procedures employed, the appendices of this report provide documentation of the LIFE2 software.

Program Routines

Appendices A through G provide documentation of each overlay in LIFE2. Following a general description of the purpose of the overlay, each appendix documents the program units (i.e., program, subroutines, functions) contained within it. The documentation for each program unit is divided into the following sections.

* The sole exception is the LIFE2 routine COMPASS, which is written in COMPASS assembly language.

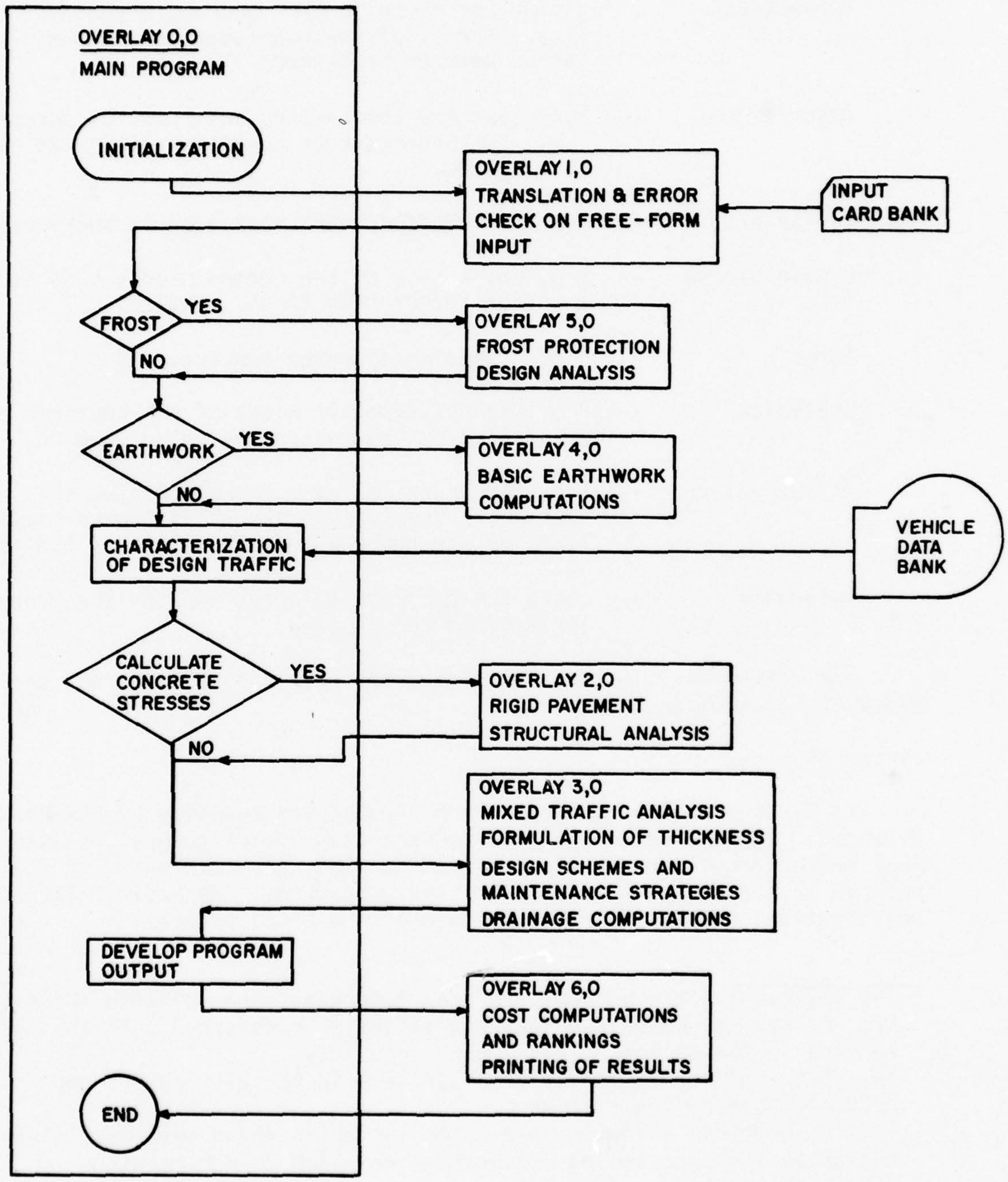


Figure 13. Framework of LIFE2 program overlays.

Purpose	---	Statement of the routine's function.
Formal Parameters	---	Provides the header card for the routine, giving the symbolic name and any arguments (i.e., formal parameters) used for communication between procedures.
Description	---	Describes how the routine achieves its purpose, i.e., the procedure or operation simulated by the routine.
Variables	---	Lists and defines variables used in the routine.*
Common Blocks	---	Provides a list of the common blocks used to transfer information to the routine.
Tapes	---	Lists tapes used by the routine.
Traceback	---	Provides the symbolic names of the routines calling and called by the routine being documented.
Illustrations	---	Presents graphical aids for describing the routine in the form of graphs or tables simulated by the routine or a flowchart of the routine.
References	---	Lists the applicable references for the procedures included in the routine.

For convenience in locating a routine, an alphabetical index precedes the appendices.

System Routines

LIFE2 uses certain system routines which are supplied by FORTRAN Extended. System routines are procedures that are of general utility or that are difficult to express in FORTRAN. They are referenced in the program in the same way as user-written procedures. Appendix H lists and describes the system routines used by the LIFE2 program.

* The following abbreviations are used throughout the variable definitions:
FP: Formal parameter; indicates a variable transferred with the routine in the statement calling the routine.
NA: Not applicable; indicates a variable in the listing but not actually used in the routine.
T.V.: Temporary variable; indicates variables which serve as intermediaries for programming convenience or which change meanings within the routine.

Error Messages

Error messages have been incorporated in various routines to help debug program input. The printed messages are self-explanatory. Appendix I lists the LIFE2 error messages by the routine in which they originate.

Vehicle Data Bank

The design procedures incorporated in LIFE2 require information about the characteristics of the vehicles for which the pavement is being designed. Since these characteristics (i.e., gross load, tire or axle spacing, etc.) will not change, they can be compiled in a data bank capable of interacting with the LIFE2 program. Appendix J gives the format used in the vehicle data bank, the current contents of the data bank, and procedures for adding new vehicles or changing existing information.

Program Flow

Figure 14 illustrates tree structures which depict the relationships of the routines within each overlay. To better understand the program's flow, the user can determine calls to and from any routine from these figures. Routines which are called in more than one place are given by circled numerals. The key at the end of the figure lists the routines with multiple calls and the number of call locations for each.

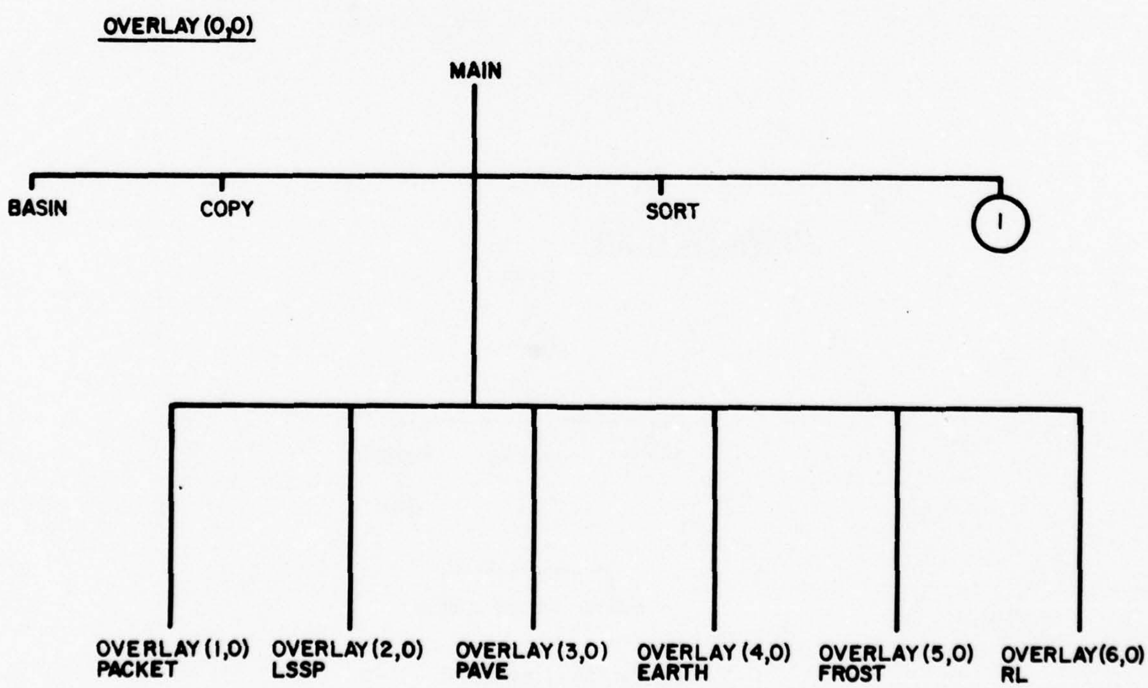
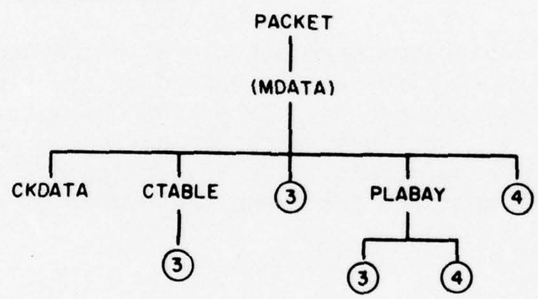


Figure 14. Overlay tree structures.

OVERLAY (1,0)



OVERLAY (2,0)

Figure 14 (cont'd).

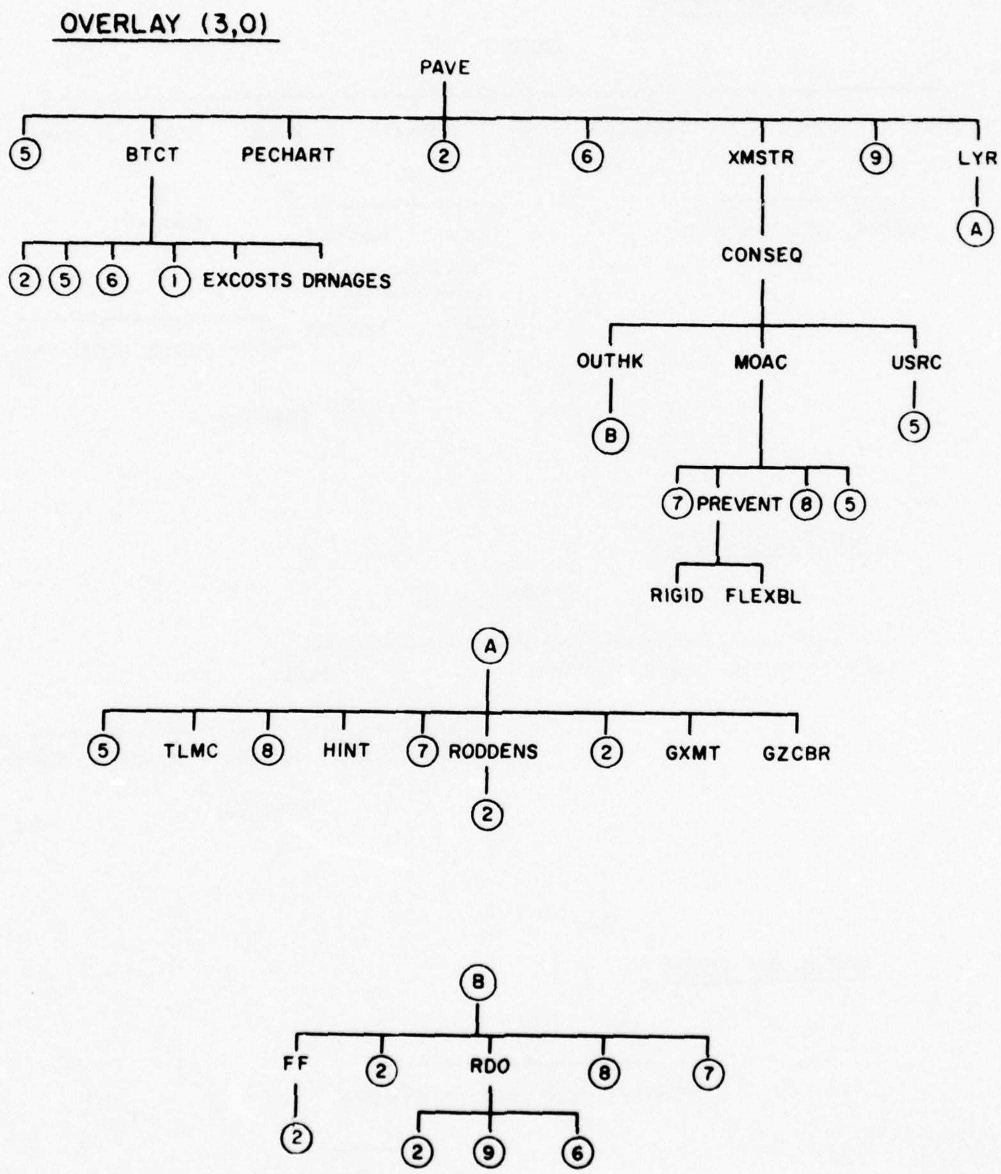


Figure 14 (cont'd).

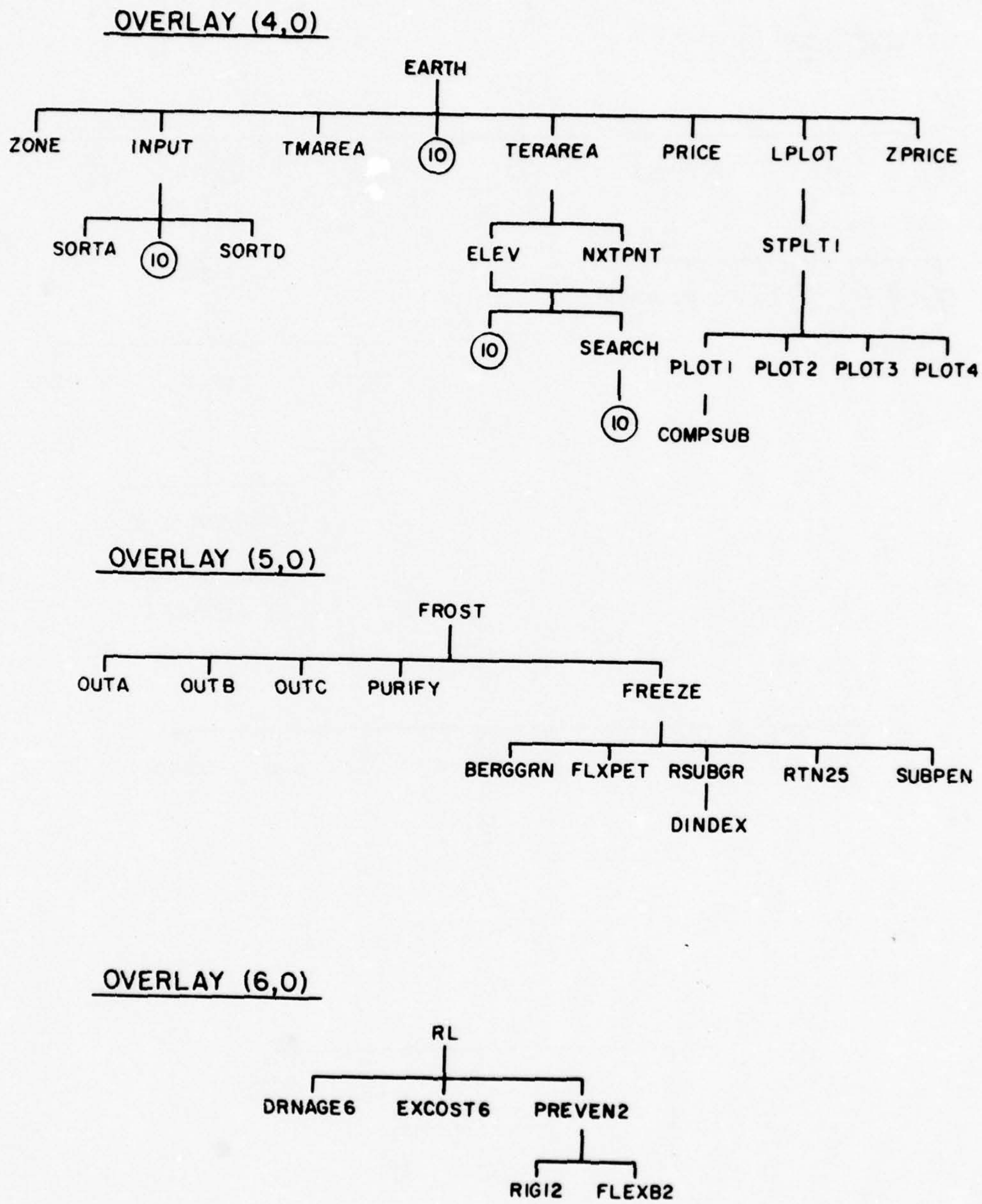


Figure 14 (cont'd).

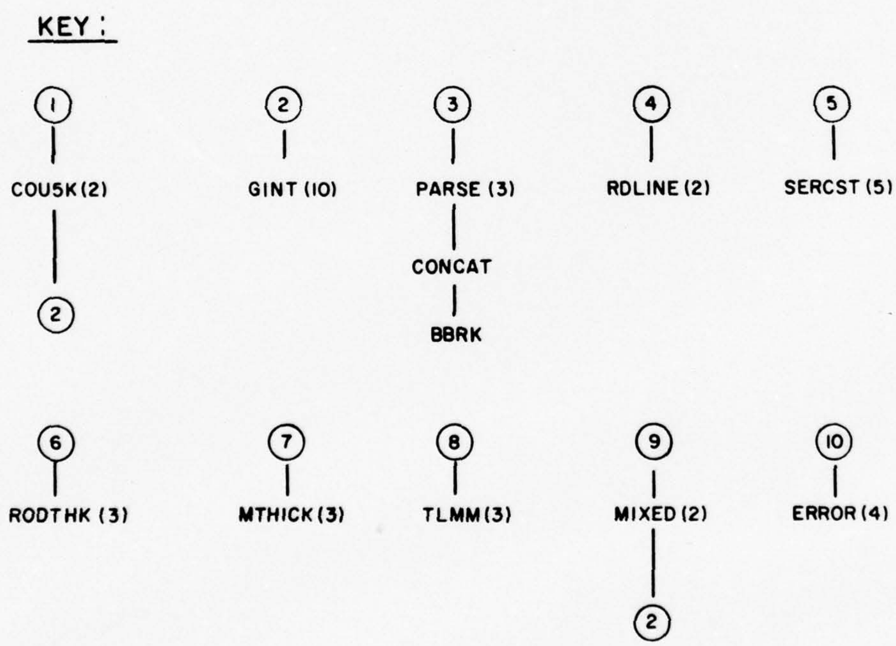


Figure 14 (cont'd).

4 CONCLUSIONS

LIFE2 is an implementable tool for helping engineers design and manage pavement facilities. It models current (1977) Corps of Engineers design criteria to enable:

1. Quick and efficient development of economical pavement designs based on construction costs

2. Performance of preliminary earthwork calculations for site location, and drainage analysis for placement of underdrains

3. Determination of economically optimal M&R strategies based on costs incurred to keep a facility functional throughout its service life

4. Development of optimal life-cycle designs and M&R strategies by combining 1, 2, and 3 above.

REFERENCES

Airfield Flexible Pavement - Air Force, TM 5-824-2 (Department of the Army, February 1969).

Airfield Rigid Pavement Evaluation-Air Force Energy Construction, TM 5-888-9/AFM 88-40, Chapter 37 (Army and Air Force, 1966).

Development of Rigid Pavement Thickness Requirements for Military Roads and Streets (Technical Report No. 4-18, Ohio River Division Laboratories, 1961).

Drainage for Areas Other Than Airfields, TM 5-820-4 (Department of the Army, 15 July 1965).

Drainage and Erosion Control--Structures for Airfields and Heliports, TM 5-820-3 (Department of the Army, 14 August 1964).

Drainage and Erosion Control--Subsurface Facilities for Airfields (Draft), TM 5-820-2 (Department of the Army, 1974).

Drainage and Erosion Control--Surface Drainage Facilities for Airfields and Heliports, TM 5-820-1 (Department of the Army, 31 August 1965).

Evaluation for Frost Conditions, TM 5-818-3 (Department of the Army, 20 December 1966).

Hammitt, G. M., et al., *Multiple-Wheel Heavy Gear Load Pavement Tests: Volume IV*, Technical Report No. 70-113 (Air Force Weapons Laboratory, November 1971).

Kreger, W. C., *Computerized Aircraft Ground Flotation Analysis--Edge-Loaded Rigid Pavement*, Report ERR-FW-572 (General Dynamics Corporation, 1967).

Lindow, E., et al., *LIFE2 User's Manual*, Technical Report C-59/ADA023186 (CERL, January 1976).

Marvin, E., and P. McManus, *Life Cycle Analysis of an Airfield Pavement Facility*, Unpublished Report (CERL, 1972).

Rigid Pavements for Airfields Other Than Army, TM 5-824-3 (Department of the Army, 7 December 1970).

Wiley, M., *The Digital Terrain System of Earthwork Computation* (U.S. Army Corps of Engineers, Kansas City District, 1972).

Wilmer, J., et al., *User Manual for LIFE1 Computer Program*, Technical Report S-28/AD#774849 (CERL, January 1974).

ROUTINE INDEX

This index alphabetically lists all LIFE2 routines (i.e., programs, subroutines, functions, block data, and externals) and lists their page location in the appendices. (Footnotes are on the last page of the index.)

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1 These routines are supplied by the computer system. Definitions are listed in Appendix H.

2 Part of SCAN package.

3 Part of H-51 program.

4 Part of setplot package.

5 DASPXXX is the entry point for routine COMPSUB.

APPENDIX A:

OVERLAY (0,0)

Overlay (0,0) is the control module for calling the remaining six computational overlays. It remains in computer memory while the other overlays are loaded and unloaded. Overlay (0,0) contains the following routines: MAIN, GINT, SORT, COV5K, BASIN, and COPY.

MAIN

Purpose

MAIN drives the LIFE2 program by determining which computations will be required and then calling the appropriate overlays in the predetermined sequence.

Formal Parameters

The header card for MAIN appears as follows:

```
PROGRAM MAIN (OUT1,OUT2,OUT3,OUT4,OUT5,OUT6,OUTPUT,INPUT,SF2,
SF3,SF5,SF7,ADATA,TAPE1=INPUT,TAPE2=SF2,TAPE3=SF3,SF3,TAPE4=OUT4,
TAPE5=SF5,TAPE6=OUT2,TAPE7=SF7,TAPE8=OUT1,TAPE9=OUT3,TAPE10=ADATA,
TAPE11=OUT5,TAPE12=OUT6)
```

Description

MAIN initially calls OVERLAY (1,0) to read and process the program input. If frost or earthwork analyses are to be performed, OVERLAY (5,0) or (4,0), respectively, would then be called. Next, COPY is called to read the vehicle data bank. MAIN tabulates traffic at intervals during the design life and then calls OVERLAY (2,0) for airfield design or COV5K for road design. Following internal conversions of the input traffic data, OVERLAY (3,0) is called to formulate structural thickness design schemes and/or maintenance strategies. Finally, MAIN calls OVERLAY (6,0) to perform cost computations and to produce the output.

Variables

Variable	Location	Usage
	A	/ABLK/ NA
AESWL(10)	/WES/	Area in sq in. of the equivalent single-wheel load (ESWL). AESWL is read from the vehicle data bank in subroutine copy, written on TAPE5, and read from TAPE5 in MAIN.
AG	/ABLK/	NA
AH	/ABLK/	NA
AHH(10)	/HBLK/	Same as HH; used for "rigid overlay over asphalt" calculations. For roads, AHH(1) is equal to thickness for 5000 coverages.
AK	/ABLK/	
AKEF(10)	/AKBLK/	Modified subgrade modulus, k, in pci. For BASE TRADEOFF, AKEF(I) is an effective k value for a base thickness I, where I is 10,20,30...100 (based on TM-5-888-9, Figure II-2). The lowest k value of AKEF(I) and AKEFT(I) is saved in AKEFT(I).
AKEFT(10)	/ABLK3/	Modified subgrade modulus, k, in pci. Used for reduced subgrade strength analysis for rigid pavements in the frost analysis. AKEFT(I) contains a calculated k for thickness I, where I=10,20,30...100.
AKY	/AKBLK/	NA
ALOS	/SA/	NA
AMINOR	/KARD/	NA
AP(10)	/ABLK/	NA
APREND(9,3)	/ZONES/	NA
APRSTR(9,3)	/ZONES/	NA
APTOT	/ZONES/	Used in earthwork analysis. Initialized to 0.0.

Variable	Location	Usage
APWID(9)	/ZONES/	NA
AREA	/ARBK/	Section area, initialized to 10^9.
ASIG(10)	/ABLK/	NA
AXK	/LCY/	An effective k for rigid overlay over asphalt design following TM-5-824-3, p 29. Calculation assumes two 6-in. (152-mm) layers of CBR=80 beneach rigid pavement.
B		FP for call to SECOND. Returns computer job elapsed time and is written on TAPE6.
BIG	/AKBLK/	NA
BMOIST	/KARD/	NA
BTE	/BSBLK/	Incremented base thickness 10,20,30...100. Used in call to BASIN for "effective k" chart.
CAVCSTO	/DRNBLK2/	NA
CBR(10)	/WES/	Array containing all the CBR values in the input; stored in the order of subgrade, compacted subgrade, subbase, and base. May be altered by subroutine SORT.
CBR10	/KARD/	NA
CBR8	/KARD/	NA
CCCST(50,10,2)	/CSTBK/	Cost array; initialized to (0.0).
CHAR(7,50)	/RL2/	Describes the type of ROUTINE, MAINTENANCE, used for output in RL.
CLNDRN	/PRUNT/	NA
CLNSWD	/PRUNT/	NA
COMPF	/BLOCKB/	NA
COMPR	/BLOCKB/	NA
COMS(4)	/KARD/	NA

Variable	Location	Usage
COSTF	/PRUNT/	NA
COSTR	/PRUNT/	NA
COVM(20)	/SG5WP2/	NA
COVRGD(10,20)	/MIXBLK/	Coverage level (I,J) for vehicle I at the year specified in TM(J) array. Since differences exist in the design index-coverages relationship for rigid and flexible pavement, COVRGD (I,J) is for rigid, and COVRGD(2,J) is for flexible.
CRSL	/PRVNT/	NA
CSTRT(10,6)	/RDSTR/	Overlay strategy array. CSTRT(I,J) is initialized to 0,0.
CUTPRCE	/TSV/	NA
DCOM(20)	SG5WP2	NA
DESIGN	/KARD/	NA
DFI	/KARD/	NA
DLCF	/CUSR/	DELAY.COST.FLEXIBLE.OVERLAY, initialized to 0,0.
DLCR	/CUSR/	DELAY.COST.FLEXIBLE.OVERLAY, initialized to 0,0.
DLO	/DRNBLK2/	NA
DRAIN	/DRNBLK2/	Drainage code, initialized to 0,0.
DRNCST	/DRNBLK/	Drainage cost, initialized to 0,0.
DRYWT	/KARD/	NA
DSC	/COND/	DISCOUNT, initialized to 0,0.
DSCRPT(3,50)	/RL2/	Array of pavement layer labels, initialized to blanks.

Variable	Location	Usage
DT	/DOBK/	DTHICKNESS, initialized to 10^7.
DT2Q	/DOBK/	NA
EARTHWK	/RL1/	EARTHWORK code. If the code equals 1 or 2, the earthwork overlay, OVERLAY (4,0), is called.
EFK		FP result from BASIN subroutine, effective k at thickness BTE, stored in array AKEF.
EPO	/DRNBLK2/	NA
ERCOST	/TSV/	NA
ESC	/COND/	ESCALATION.RATE, initialized to (0.0).
ESWL(10,20)	/WES/	Equivalent single-wheel load in pounds per sq in. ESWL is read off TAPE5 as a weight, and divided by AESWL to get a pressure.
FAC	/LCY/	Pass/coverage ratio; set according to the type of vehicle and WANDER.
FACC	/IABLK/	Pass/coverage ratio for channelized traffic of a particular vehicle; read from the vehicle data bank in subroutine COPY.
FACN	/IABLK/	Pass/coverage ratio for unchannelized traffic of a particular vehicle; read from the vehicle data bank in subroutine COPY.
FACTOR	/RL1/	Initialized to 1.0.
FACTR1	/PRVNT/	NA
FACTR2	/PRVNT/	NA
FACTR3	/PRVNT/	NA
FCOMPF	/BLOCKB/	NA
FCOMPR	/BLOCKB/	NA

Variable	Location	Usage
FDE	/BSBLK/	Frost depth estimate read from FROST. DESIGN input; initialized to 1.0.
FDEF	/BSBLK2/	NA
FILCSTO	DRNBLK2/	NA
FILPRCE	/TSV/	NA
FK1		Scale factor used in PAVE to adjust thicknesses in the HH array based on the actual k value. The original thicknesses are computed for k=25-200 pci. FK1 is a scale factor for k=300-399. (From AFWL TR 70-113, Figure 43.)
FK2		Same as FK1, except k=400-499.
FK3		Same as FK1, except k=200-299.
FLEXPT	/KARD/	NA
FLSF	/BLOCKB/	NA
FLSR	/BLOCKB/	NA
FRSTSL	/PRVNT/	NA
FRSUBF	/BLOCKB/	NA
FRSUBR	/BLOCKB/	NA
GBM	/BSBLK/	Index for GRANULAR.BASE.MATERIAL. FP for subroutine BASIN. GBM is 1 for WELL.GRADED.CRUSHED.MATERIAL, and 2 for NATURAL.SAND.AND.GRAVEL.
HH(10)	/HBLK/	Array containing 10 equally spaced thicknesses with end points defined by RANGE.OF.THICKNESS. For roads, HH(1) contains the design thickness for 5000 coverages from subroutine COV5K.
H30	/DRNBLK2/	NA
I		T.V.

Variable	Location	Usage
IA	/IABLK/	Index for wheel type for a particular vehicle: 02 for twin-tandem, and 00 for all others.
IAA(10)	/LTTBLK/	Array containing the wheel type index for each vehicle.
IAXK	/KAYBK/	No longer used input variable to allow or disallow rigid pavement over flexible. Internally set to allow this arrangement (=1).
IB		T.V.
IBN	/AMBLK/	Bonding code for rigid overlays; initialized to 3.
IBTE	/BSBLK/	BASE.TRADEOFF and FROST.DESIGN; index as follows:

IBTE	Tradeoff Action	Frost Action
1	none	none
2	unavailable	option
3	tradeoff	can be read
4	tradeoff	read
5	tradeoff	calculate
6	none	calculate

Variable	Location	Usage
ICBR	/MXBLK/	Number of CBRs in the CBR array. May be increased or decreased by subroutine SORT.
ICOND	/COND/	CONDITION index; initialized to 1.
ICONFIG	/KARD/	NA
ICOUNT	/RESTR/	NA
ICYCLE	/PRVNT/	NA
ID	/DOBK/	CALCULATION.TYPE index: 1 = maintenance, 2 = life-cycle, 3 = design.

Variable	Location	Usage
IDENT(3)	/RL1/	Initialized to blanks.
IDF	/RODLOD/	Index for DESIGN.INDEX.FLEXIBLE.
INDGWTO	/DRNBLK2/	NA
IDIPO	/DRNBLK2/	NA
IDR	/RODLOD/	Index for DESIGN.INDEX.RIGID.
IDRY	/SUBK/	CLIMATE index: 1 for normal, 2 for dry.
IDSCRPT(3,10)	/RL2/	DESCRIPTION, initialized to blanks.
IE		T.V.
IFCON	/FCON/	Initialized to 2.
IFGRP	/KARD/	Frost soil classification: 1 is F1 subgrade, 2 is F2 subgrade, 3 is F3 subgrade.
IFL	/PRVNT/	NA
IFLEXNA	/BLOCKD/	Frost protection method index for flexible designs.
IFSWIT(10)	/ABLK3/	NA
IG		T.V.
IGINT	/MXBLK/	Initialized to 0.
II		T.V.
IIPAVT	/BLOCKC/	NA
IMAN	/RDSTR/	Initialized to 2.
IMIX	/MIXBLK/	Number of vehicles.
IND	/TMPL/	NA
IPAVT	/KARD/	NA

Variable	Location	Usage
IREST	/RESTR/	Index for DESIGN.RESTRICTION (initialized to 1): 1-none, 2-rigid, 3-flexible.
IRG	/PRVNT/	NA
IRIGDNA	/BLOCKD/	Frost protection method index for rigid design.
IRL	/BLBLK/	Initialized to 2.
ISKIP	/PRVNT1/	Initialized to 1.
ISUBCBR	/KARD/	NA
ISUBHOR	/KARD/	NA
ISWITF	/BLOCKC/	NA
ISWITR	/BLOCKC/	NA
ITY	/DOBK/	DTYPE (initialized to 10^7): 1-rigid, 2-flexible.
IUBC	/SUBK/	Initialized to 10^7.
IVM	/PRUNT1/	Initialized to 0.
IX		T.V.
J		T.V.
JACK	/TMPL/	NA
JCOND	/FLAG/	NA
JCYCLE	/PRVNT/	NA
JDL	/SCAN3/	DESIGN.LIFE of pavement in years.
JISKIP	/PRVNT1/	Initialized to 0.
JJ	/MIXBLK/	T.V.
JMAN	/MANLK/	Initialized to 1.

Variable	Location	Usage
JREST	/RESTR/	Initialized to 1.
JTYPE(3,10)	/RLMN/	Array containing the vehicle name. Each name is divided into 3 parts of 4 symbols each.
JXX(20,20)	/MANLK/	Initialized to 10^7.
K4	/RL1/	NA
K7	/RL1/	Initialized to 0.
LCIND	/KARD/	NA
LENGTHO	/DRNBLK2/	NA
LFUNC	/TYPBK/	Initialized to 10^7.
LLL		T.V.
LMH	/TYPBK/	LOAD.CATEGORY initialized to 10^7.
LO		T.V.
LOCATE(8)	/RL2/	Initialized to blanks.
LOUTO	/DRNBLK2/	NA
LR	/MIXBLK/	T.V.
LS	/LCY/	Number of years specified by the TIMES input for the TM array.
LT	/IABLK/	Code for the landing gear type for a particular vehicle: 01 for tricycle (and roads), and 02 for bicycle.
LTT(10)	/LTTBLK/	Array containing the LT value for each vehicle.
LZ	/RODLOD/	Code for road design: 3 for road design; otherwise airfield design.
MESS(110	/BLOCKC/	NA
MLYST	/MANLK/	Initialized to 10^7.

Variable	Location	Usage
MMM		T.V.
MNT	/DOM/	Initialized to 10^7.
MNTO	/SZBK/	Initialized to 1.
MSGSW1	/BLOCKC/	NA
MSGSW2	/BLOCKC/	NA
MSGSW3	/BLOCKC/	NA
MXN	/AMBLK/	Initialized to 10.
MXTO	/SZBK/	Initialized to 30.
NAME(5)	/RL2/	Initialized to blanks.
NAPR	/ZONES/	NA
NB	/LYTD/	Number of bases.
NCOM	/LYTD/	Number of compacted subgrades.
NFL	/PRVNT/	NA
NFLEX	/TYP/	Set to zero if DESIGN.RESTRICTION and OVERLAY.RESTRICTION are FLEXIBLE.
NLYST	/NANLK/	NA
NNAT	/LYTD/	Number of natural subgrade layers.
NOACFT(50,10)	/RLMN/	Number of passes of a particular vehicle in a particular year.
NOD	/NBLK/	NA
NOG	/NBLK/	NA
NOGWT	/SG5WP2/	NA
NOH	/NBLK/	Number of thicknesses in the HH array.
NOO(10)	/RDSTR/	Initialized to 0.

Variable	Location	Usage
NOSG	/NBLK/	NA
NOUTO	/DRNBLK2/	NA
NP	/SCAN3/	Index for WANDER: 1-CHANNELIZED, 2-UNCHANNELIZED.
NPT	/NBLK/	NA
NREX2	/SG5WP2/	NA
NRG	/PRVNT/	NA
NRIGID	/TYP/	Set to zero if DESIGN.RESTRICTION and OVERLAY.RESTRICTION are RIGID.
NSBB	/LYTD/	Number of subbase layers.
NUMS	/RDSTR/	NA
NX	/NBLK/	NA
NY	/NBLK/	NA
NYOO(20)	/MANLK/	Initialized to 10^7.
OMTF	/MTO/	MINIMUM THICKNESS.FLEXIBLE.OVERLAY; initialized to 4.0.
OMTR	/MTO/	MINIMUM THICKNESS, RIGID OVERLAY; initialized to 5.0.
OUR	/KARD/	NA
PAVT	/AKBLK/	NA
PERMO	/DRNBLK2/	NA
PIPCSTO	/DRNBLK2/	NA
PRDBTF	/BLOCKB/	NA
PRDBTR	/BLOCKB/	NA
PRFLTF	/BLOCKB/	NA

Variable	Location	Usage
PRFLTR	/BLOCKB/	NA
PSTEP	/TSV/	NA
PTCH	/PRVNT/	NA
PVTFLX	/BLOCKD/	NA
PVTRGD	/BLOCKD/	NA
REPFL(10,2)	/PRVNT/	NA
REPRG(10,2)	/PRVNT/	NA
RIGDPT	/KARD/	NA
RK		T.V.
RRO	/DRNBLK2/	NA
RSUBF	/BLOCKB/	NA
RSUBR	/BLOCKB/	NA
S	/SBLK/	NA
SCLPOP	/PRVNT/	NA
SIGMA(10)	/SBLK/	NA
SLCT	/PRUNT/	NA
SLO	/DRNBLK2/	NA
SLSDBTF	/BLOCKB/	NA
SLSDBTR	/BLOCKB/	NA
SLSPENF	/BLOCKB/	NA
SLSPENR	/BLOCKB/	NA
SMOIST	/KARD/	NA
SR	/SBLK/	NA

Variable	Location	Usage
STORE1(10,10)	/MIXBLK/	Array containing the 10 concrete stresses on grade for the 10 thicknesses in the HH array; calculated in OVERLAY (2,0). For an aircraft with a bicycle gear, these stresses are increased by 20 percent (see Hutchinson reference).
STORE2(10,10)	/MIXBLK/	Array containing the 10 concrete stresses over asphalt for the 10 thicknesses in the HH array; calculated in OVERLAY (2,0). For an aircraft with a bicycle gear, these stresses are increased by 20 percent (see Hutchinson reference).
SUBD	/SUBK/	SUBGRADE.DENSITY, initialized to 10^7.
SUBMOD	/KARD/	NA
SWID	/TMPL/	NA
T		T.V.
TBS	/AKBLK/	NA
TCY(50)	/SCAN3/	NA
TDFP	/KARD/	NA
THCK	/TSV/	NA
THFF(20)	/THKBK/	NA
TM(20)	/HBLK/	Array containing the years specified for thickness calculations, as input by the user via the TIMES variable or as calculated in the program by default values.
TR		T.V.
TRAFF	/KARD/	NA
TRF		T.V. (necessitated by the flexible design index for road design).
TRKK(20)	/THKBK/	NA

Variable	Location	Usage
TRL(10)	/SCAN3/	PAST.TRAFFIC for each vehicle.
TRPQZ(20)	/PQZ/	NA
TRST	/DMBLK/	Initialized to 0.0.
TRY(20)	/LCY/	T.V.
TRYF(20)		T.V.
TWOCL	/TMPL/	NA
WHEELS(10)	/WES/	Number of wheels on each vehicle; used to compute the equivalent single-wheel load.
WOS	/SA/	NA
XCBR	/LCY/	SUBGRADE.CBR.
XFP(20,10)	/SG5WP2/	NA
XH		T.V. (output from subroutine COV5K which is pavement thickness of 5000 coverages in road design).
XK	/NBLK/	SUBGRADE.MODULUS.
XMT(10,6)	/LYTD/	Array containing properties of the subbase layers. XMT(I,1) contains the CBR of layer I.
XSTR	/LCY/	CONCRETE.FLEXURAL.STRENGTH (psi).
XTRA	/BLOCKB/	NA
YCBR(10,4)	/LYTD/	Array containing properties of the natural subgrade layers.YCBR (I,1) contains the CBR of layer I.
YK	/LCY/	T.V.
ZCBR(10,6)	/LYTD/	Array containing properties of the compacted subgrade layers. ZCBR(I,1) contains the CBR of layer I.

Variable	Location	Usage
ZMT(3,4)	/LYTD/	Array containing the base CBRs.
ZONSTEP	/ZONES/	NA

Common Blocks

Common blocks contained in MAIN are:

ABLK, ABLK3, AKBLK, AMBLK, ARBK, BLBLK, BLOCKB, BLOCKC, BLOCKD, BSBLK, BSBLK2, COND, CSTBK, CUSR, DMBLK, DOBK, DOM, DRNBLK, DRNBLK2, FCON, FLAT, HBLK, IABLK, KARD, DAYBK, LCY, LTTBLK, LYTD, MANLK, MIXBLK, MTD, MXBLK, NANLK, NBLK, PQZ, PRVNT, PRVNT1, RDSTR, RESTR, RLMN, RL1, RL2, RODLOD, SA, SBLK, SCAN3, SG5WP2, SUBK, SZBK, THKBK, TMPL, TSV, TYP, TYPBK, WES, ZONES.

Tapes

The tapes used by MAIN are:

TAPE 1 - job input tape,

TAPE 2 - scratch file, SF2

TAPE 3 - scratch file, SF3

TAPE 4 - earthwork output file, OUT4

TAPE 5 - scratch file, SF5

TAPE 6 - debug file, OUT2

TAPE 7 - scratch file, SF7

TAPE 8 - LIFE2 output file, OUT1

TAPE 9 - frost analysis output file, OUT3

TAPE 10 - vehicle data bank, ADATA

TAPE 11 - earthwork mass diagram plot, OUT5

TAPE 12 - drainage analysis output, OUT6

Traceback

MAIN calls BASIN, COPY, COV5K, and SORT in OVERLAY (0,0) as well as OVERLAY, REMARK, and SECOND from the CDC Library.

Illustrations

Figure A1 is a descriptive flowchart of MAIN.

References

G. M. Hammit, *Multiple Wheel Heavy Gear Load Pavement Tests*, Vol IV, AFWL TRM70-113 (Air Force Weapons Laboratory, 1971).

Rigid Pavements for Airfields Other Than Army, TM-5-824-3 (Department of the Army, 7 December 1970), p 29.

Airfield Rigid Pavement Evaluation -- Emergency Construction, TM-5-888-9, Figure II-2 (Department of the Army, December 1966).

R. L. Hutchinson, *Basis for Rigid Pavement Design for Military Aircraft*, Miscellaneous Paper 5-7 (Ohio River Division Laboratory, May 1966).

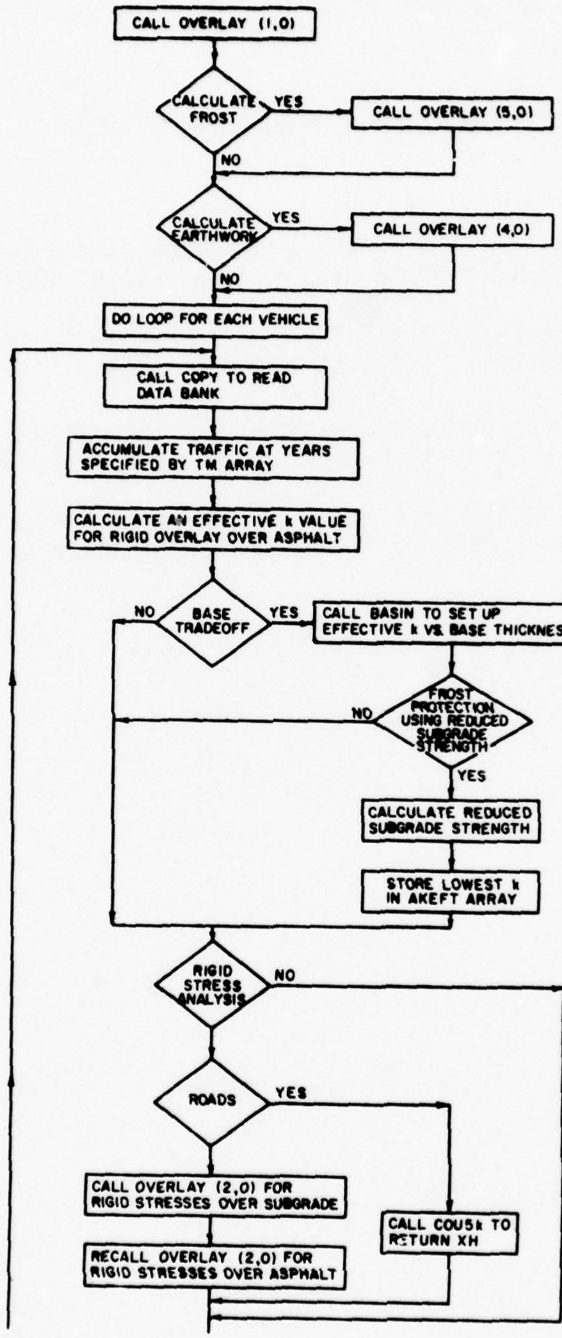

Figure A1. Main flowchart.

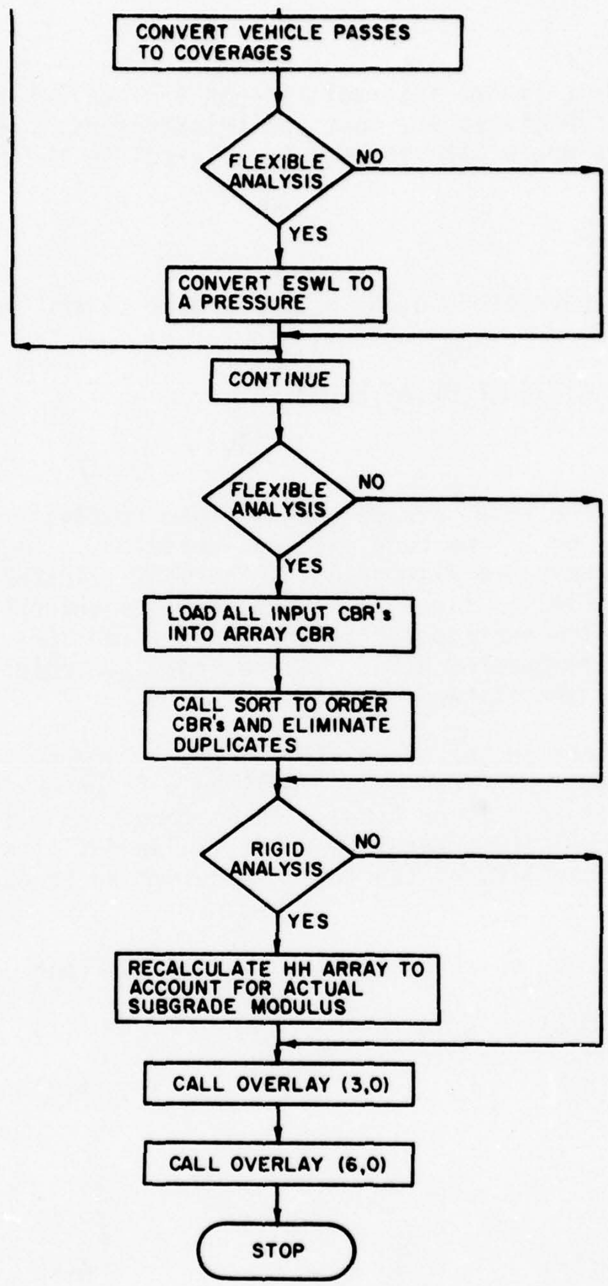

Figure A1 (cont'd).

GINT

Purpose

GINT performs linear interpolation on various related one-dimensional arrays. Thickness vs. cost and thickness vs. time curves are examples of arrays where GINT is used to interpolate the dependent variable.

Formal Parameters

The formal parameters used in GINT appear on the header card as follows:

SUBROUTINE GINT(H,P,BP,AP,K,LD).

Description

GINT reads the input arrays H and P into temporary arrays A and B. This protects H and P from undesired manipulations. Any duplicate points in the arrays are eliminated. Figure A2 illustrates the procedures used in GINT to linearly interpolate the unknown value for variable A(P) which corresponds to the known value B(P). The array members B(X) and B(Y) bracket B(P). Several possible relationships of B(P) to B(X) and B(Y) are allowed.

If B(P) is not in the range B(1) to B(LD) (where LD is the number of array members), an error message will be written on TAPE 6, and A(P) will be set equal to A(1) or A(LD). Three conditions will cause a STOP to be executed: (1) LD greater than 99, (2) an infinite slope to the curve, and (3) inability of the logic to determine bracketing value in array B.

B Array (e.g., thickness)	A Array (e.g., cost)
B(1)	A(1)
B(2)	A(2)
.	.
.	.
.	.
B(x)	A(x)
B(P)	A(P)*
B(Y)	A(Y)

B Array (e.g., thickness)	A Array (e.g., cost)
.	.
.	.
.	.
B(LD)	A(LD)

A(P) is the cost associated with thickness B(P) in this example.

Variables

Variable	Location	Usage
A(I)		Dummy array duplicating the H array.
AP	FP	Output value corresponding to B(P).
B(I)		Dummy array duplicating the P array.
BJM		T.V.
BK		T.V.
BLEEP		Used to compare B array members for duplicity.
BP	FP	Input value (e.g., thickness) for which interpolation of a corresponding value is desired.
BP1		T.V. (used when BP might be beyond the range of the B array).
BP2		T.V. (used when BP might be beyond the range of the B array).
BP3		T.V. (used when BP might be beyond the range of the B array).
BSAVE		Used to compare B array members for duplicity.
D(I)		T.V. (used to bracket BP).
H(I)	FP	Array from which AP is interpolated; related on one-to-one basis to P(I).
I		T.V.
IBACK		Counter (number of duplicate end points in B array).

Variable	Location	Usage
IFRONT		Counter (number of duplicate begin points in B array).
ISTOP		Flag if begin point of B array is duplicate.
ITR		T.V.
J		T.V. (used to bracket BP).
JSTOP		Flag if end point of B array is duplicate.
K	FP	Number of H and P array members; used as counter.
L		T.V. (number of B array members left after removing duplicates).
LD	FP	Number of H and P array members; used to dimension arrays.
M		T.V. (used to bracket BP).
N		T.V. (used to bracket BP).
P(I)	FP	Array into which BP is compared; related on a one-to-one basis to array H(I).
SL		Difference between the bracketing points in the A array.
SLD		Difference between the bracketing points in the B array.
X		T.V. (used to bracket BP).
Y		T.V. (used to bracket BP).

Common Blocks

None.

Tapes

The tape used by GINT is: TAPE 6 - debug file; writes error messages.

Traceback

GINT is called by BTCT, PAVE, LYR, OVTHK, RDO, and FF.

Illustrations

Figure A2 illustrates the linear interpolation used in GINT.

References

None.

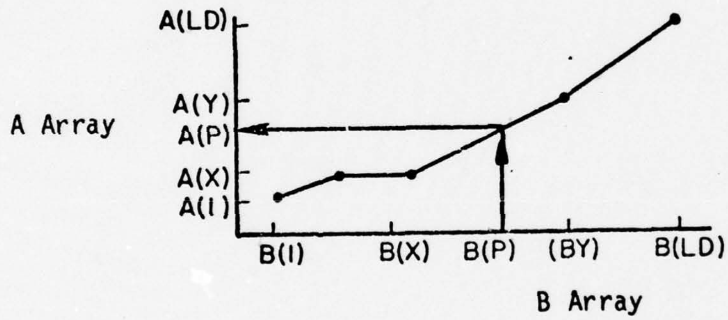

Figure A2. Interpolation procedure in GINT.

SORT

Purpose

SORT catalogs each material available for flexible pavement design by its associated CBR value. The CBR values are ordered from lowest to highest for subsequent use in structural thickness design for flexible pavements.

Formal Parameters

The formal parameters used in SORT appear on the header card as follows:

SUBROUTINE SORT (A,N).

Description

SORT obtains CBR information for each material from MAIN. A one-dimensional array is then formed, starting with the lowest CBR value available and increasing to the highest value; duplicate values are eliminated.

Variables

Variable	Location	Usage
A(N)	FP	Array from MAIN containing all input CBRs. Following SORT, duplicate values are eliminated.
C		T.V. for A(I).
I		T.V.
IP		T.V.
J		T.V.
N	FP	Number of CBRs in A array.
TEMP		T.V. for A(I).

Common Blocks

None.

Tapes

The tape used by SORT is: TAPE 6 -- Debug file and writes error messages.

Traceback

SORT is called by MAIN.

Illustrations

None.

References

None.

COV5K

Purpose

COV5K computes rigid pavement thickness for 5000 coverages, given the concrete flexural strength and subgrade modulus of reaction.

Formal Parameters

The formal parameters used by COV5K appear on the header card as follows:

SUBROUTINE COV5K (XK,FS,RPAV).

Description

COV5K uses the input concrete flexural strength (allowable range from 550 to 800 psi) and the subgrade modulus of reaction, (allowable range from 25 to 500 pci) to compute the rigid pavement thickness for 5000 coverages of a basic loading (see Figure 4 of the Ohio River Division Laboratory's TR 4-18 for this subroutine). The thickness is subsequently modified for the design traffic and other limiting parameters to produce the rigid structural thickness for a design scheme.

Variables

Variable	Location	Usage
CONFLX(11)		Flexural strength axis for TR 4-18, Figure 4.
DEL(11)		Reference variables corresponding to k values.
DM		Point on reference axis.
DUM		Interpolated value from DEL array.
FS	FP	Concrete flexural strength in psi.
I		T.V.
K		T.V.
KH		Upper boundary k curve.
KK(2)		Array of lower and upper k values.

Variable	Location	Usage
KL		Lower boundary k curve.
K100(11)		Curve for k=100 pci.
K200(11)		Curve for k=200 pci.
K25(11)		Curve for k=25 pci.
K300(11)		Curve for k=300 pci.
K400(11)		Curve for k=400 pci.
K50(11)		Curve for k=50 pci.
K500(11)		Curve for k=500 pci.
L		T.V.
PAVY(22)		Thickness axis, related to REFY.
REF(22)		Reference axis, related to PAVY.
RPAV	FP	Output thickness for 5000 coverages.
XK	FP	Actual k value.

Common Blocks

None.

Tapes

COV5K uses the following tape: TAPE 8 -- output file; writes error messages.

Traceback

COV5K is called by MAIN and BTCT and calls GINT.

Illustrations

Figure A3 is the programmed version of Figure 4 in TR 4-18 which is modeled by COV5K. For a given flexural strength (FS) and k value, a unique thickness for 5000 coverages of a basic loading can be determined. The reference axix (bottom of Figure A3) was added to facilitate programming.

References

Development of Rigid Pavement Thickness Requirements for Military Roads and Streets, Technical Report No. 4-18 (Corps of Engineers, Ohio River Division Laboratories, July 1961).

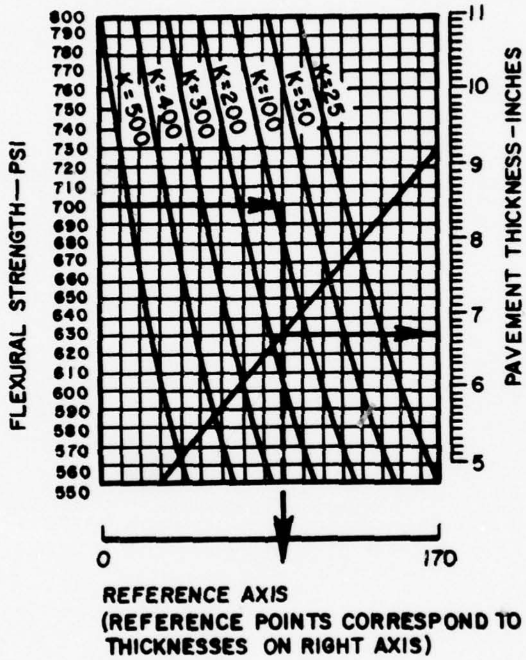

Figure A3. Design curves for rigid pavements based on 18,000-lb, single-axle loads. (Dual wheels - 13.5 x 58.5 x 13.5 in. [342.9 x 1485.9 x 342.9 mm]).

BASIN

Purpose

BASIN is used to determine the effective k at the surface of a base course for use in rigid pavement designs. The effective k is the modulus of reaction (in pci) for the combined base and subgrade materials.

Formal Parameters

The formal parameters used in BASIN appear on the header card as follows:

SUBROUTINE BASIN (GBM,BTE,EFK).

Description

BASIN computes the effective k for use in rigid pavement design based on Figure II-2 of TM-5-888-9. Figure II-2 expresses empirical relationships of base thickness, subgrade k, and effective k for both well-graded crushed stone and for natural sand and gravel. From input of subgrade k and type of base material, BASIN computes an effective k for the base thickness (BTE). BTE is incremented in MAIN from 10 to 100 in. (254 to 2540 mm). The effective k is subsequently used to determine the economically optimum combination of base and rigid pavement thicknesses (base-tradeoff).

Variables

Variable	Location	Usage
AKAY(5)		k values used for interpolation.
B		T.V.
BTE	FP	Base thickness.
EFK	FP	Computed effective k.
EFKA(5)		Array of effective k values.
GBM	FP	Code for GRANULAR.BASE.MATERIAL: 1=WELL.GRADED.CRUSHED.MATERIAL 2=NATURAL.SAND.AND.GRAVEL.
I		T.V.
J		T.V.

Variable	Location	Usage
NOD	/NBLK/	NA
NOG	/NBLK/	NA
NOH	/NBLK/	NA
NOSG	/NBLK/	NA
NPT	/NBLK/	NA
NSAG(5,5)		Points defining effective k curves for NATURAL.SAND.AND.GRAVEL.
NX	/NBLK/	NA
NY	/NBLK/	NA
WGCM(5,5)		Points defining effective k curves for WELL.GRADED.CRUSHED.MATERIAL.
XK	/NBLK/	Actual subgrade k value.

Common Blocks

The common block contained in BASIN is NBLK.

Tapes

None.

Traceback

BASIN is called by MAIN.

Illustrations

Figure A4 is the set of curves modeled by BASIN to compute the effective k.

References

Airfield Rigid Pavement Evaluation -- Emergency Construction, TM-5-88-9, Figure II-2 (Department of the Army, December 1966).

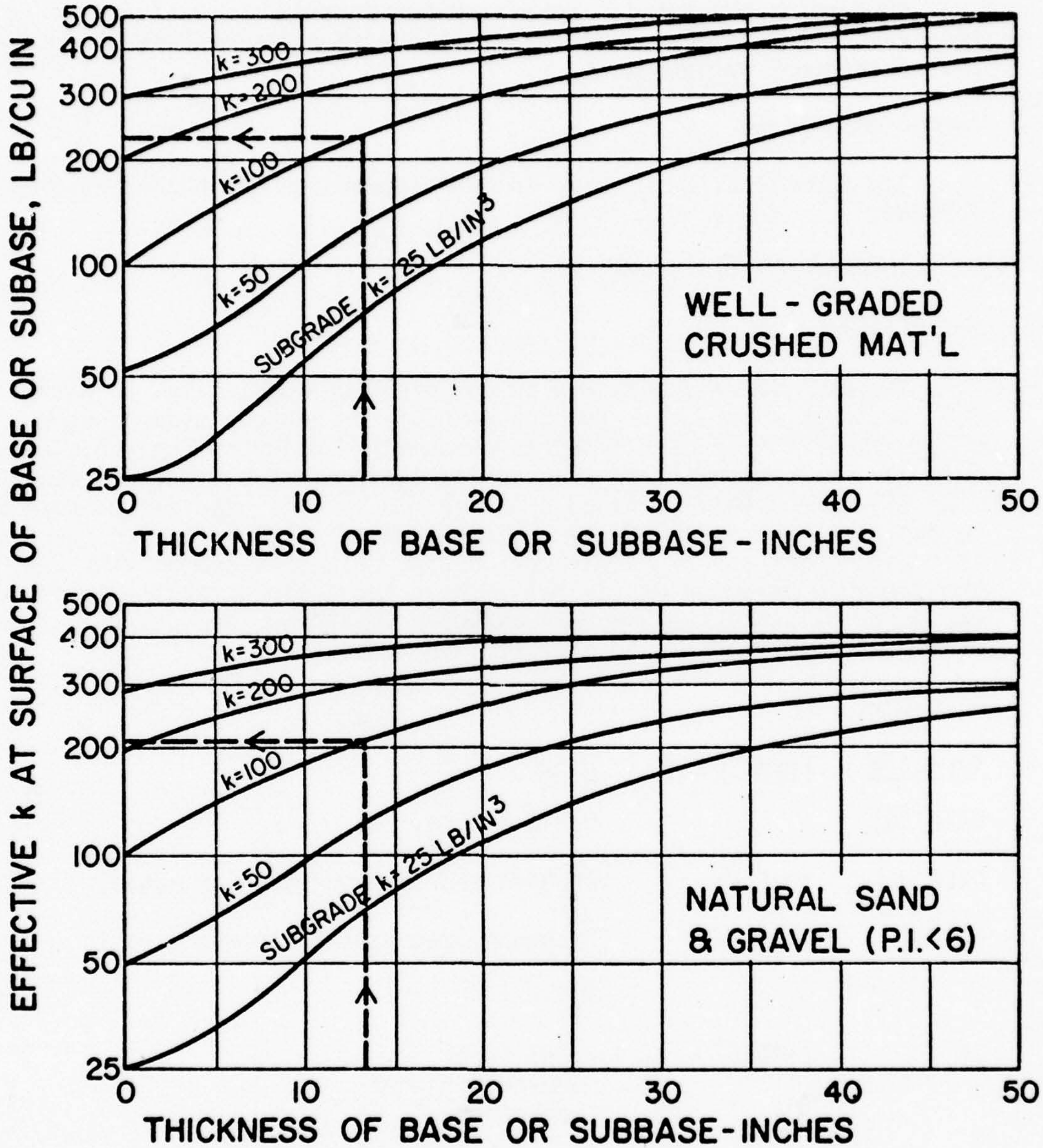

Figure A4. Effect of base or subbase thickness on modulus of subgrade reaction. (From Airfield Rigid Pavements Evaluation-Air Force Energy Construction, TM 5-888-9 [Department of the Army, December 1966]).

COPY

Purpose

COPY reads the vehicle data bank to identify the vehicle type(s) required. The vehicle characteristics are then assigned to the appropriate internal variables.

Formal Parameters

The formal parameter used in COPY appears on the header card as follows:

SUBROUTINE COPY (NAME).

Description

The vehicle data bank may be contained on tape, file, or cards. COPY scans this data bank for the name of the vehicle under consideration. If EOF (end of file) is encountered prior to the vehicle name, an error statement will be printed and the program stopped. A dollar sign ($) immediately followed by a vehicle name is used in the data bank to designate the start of the vehicle's data. The first time the symbol is found begins the rigid pavement design data; the second time begins the flexible pavement design data. When the desired vehicle is found, the data following its name are assigned to appropriate internal variables, and a return to MAIN is executed.

Variables

Variable	Location	Usage
DATA(20)		Vehicle data.
FACC	/IABLK/	Channelized pass-to-coverage ratio.
FACN	/IABLK/	Unchannelized pass-to-coverage ratio.
I		T.V.
IA	/IABLK/	Wheel type: 02-twin tandem 00-other.
IDS		First character of a line of data.
IDSC		The character "$". IDSC is compared to IDS to check for the first line of data for a vehicle.

Variable	Location	Usage
LABEL(3)	/IABLK/	Vehicle name on TAPE 10.
LT		Landing gear type: 01-tricycle 02-bicycle.
NAME(I)	FP	Vehicle name.

Common Blocks

The common block in COPY is IABLK.

Tapes

The tapes used by COPY are:

TAPE 5 -- receives flexible pavement design data

TAPE 7 -- receives rigid pavement design data

TAPE 8 -- writes error messages

TAPE 10 -- contains vehicle data bank.

Traceback

COPY is called by MAIN and calls EOF.

Illustrations

None.

References

None.

APPENDIX B:

OVERLAY (1,0)

OVERLAY (1,0) is designed to read and process the program input. Fixed format input for the frost, drainage, and earthwork analyses are read onto tapes for later use. The remainder of the input is in free format, which is decoded and equated to internal variables. The input is checked for completeness according to user-selected options. If errors or missing input are detected, a message is written to the user, and the program is stopped. Default values for appropriate variables are also assigned in this overlay.

These operations are accomplished by using PROGRAM PACKET, BLOCK-DATA, MDATA, subroutines CKDATA, PLABAY, AND CTABLE, and the SCAN package, which contains subroutines PARSE, RDLINE, CONCAT, BBRK, and BACKUP.

PACKET

Purpose

PACKET controls the input translation and error checking procedures in the program.

Formal Parameters

Since PACKET has no formal parameters, the header card would appear as PROGRAM PACKET.

Description

PACKET is the control for OVERLAY (1,0). It receives the decoded input information from SUBROUTINE PARSE, which is in the SCAN package of this overlay. The formal parameters for PARSE (ENTITY, MODE, VALUE, and NCHAR) provide the necessary information. PACKET compares each ENTITY against an input dictionary to establish the correct location for the input variable. PACKET then performs the necessary manipulations to assign the ENTITY and its associated data to that location in the proper internal form used by the program.

Variables

Variable	Location	Usage
AAME(5)	/RL2/	Array containing NAME.OF.BASE.
ADENT(3)	/RL1/	Array containing IDENTIFICATION. NUMBER.
ADSCRP(30,10)	/RL2/	Array containing GENERAL. DESCRIPTION.
ALIST(30)	/SCAN2/	Array containing symbols for input variables from A to FED as defined in MDATA.
ALOS	/SA/	LENGTH.OF.SECTION (in feet).
AOCATE(8)	/RL2/	Array containing LOCATION.OF.BASE.
ATYPE(3,10)	/RLMN/	Array containing VEHICLE.TYPE.
AXK	/LCY/	NA
BLANK		Character string of all blanks
BLIST(30)	/SCAN2/	Array containing symbols for input variables from FO to RETU as defined in MDATA.
BTAR(6)		Character array for identifying options for BASE.TRADEOFF 1=NO 2=ESTI (no longer used) 3=TRAD (TRADEOFF).
BTE	/BSBLK/	NA
CAUSTO	/DRNBLK2/	Excavation cost for drainage (in $/cy).
CCCST(50,10,2)	/CSTBK/	Array for cost curve data where CCST (I,1,1) is the number of curve segments for variable I; CCCST (I,J,1) is the value on the abscissa for the (J-1) cost data repair; and CCCST (I,J,2) is the value on the ordinate for the (J-1) cost data pair (i.e., the cost).

Variable	Location	Usage
CHAN		Character string for channelized WANDER.
CHAR(7,50)	/RL2/	Array containing cost curve labels used in program output.
CLIST(30)	/SCAN2/	Array containing symbols for input variables from RM to Z as defined in MDATA.
CCNDRN	/PRVNT/	Variable for cost/sy for MAINTAIN. DRAINS.
CLNSWP	/PRVNT/	Cost/sy for CLEANING.SWEEPING FLEXIBLE.PAVEMENT.
COSTF	/PRVNT/	Cost/sy for OTHER.MAINTENANCE. FLEXIBLE.PAVEMENT.
COSTR	/PRVNT/	Cost/sy for OTHER.MAINTENANCE. RIGIDPAVEMENT.
COVRGD(10,20)	/MIXBLK/	NA
CRSL	/PRVNT/	Cost/sy for CRACKSEALING. FLEXIBLE.PAVEMENT.
CSTRT(10,6)	/RDSTR/	Array containing TIMES.OF. OVERLAYS; CSTRT (I,J) where: I is strategy number J is years of the overlay.
DESB		Character string for CALCULATION. TYPE MAINTENANCE.
DESC		Character string for CALCULATION. TYPE LIFE-CYCLE.
DESI		Character string for CALCULATION. TYPE DESIGN.
DLCF	/CUSR/	Cost for delays due to construction of a flexible overlay.
DLCR	/CUSR/	Cost for delays due to construction of a rigid overlay.

Variable	Location	Usage
DLO	/DRNBLK2/	Drainage length in feet.
DRAIN	/DRNBLK/	Drainage Code 1=NO 2=YES 3=FIXED DEPTH.
DRNCST	/DRNBLK/	NA
DSC	/COND/	Value of DISCOUNT.
DSCRPT(3,50)	/RL2/	Array containing cost curve labels used in program output.
DT	/DOBK/	Value of DTHICKNESS of existing pavement; i.e., total thickness for flexible, slab thickness for rigid.
DT2Q	/DOBK/	NA
EARTHWK	/RL1/	Earthwork code 0=NO 1=PAVEMENT 2=PAVEMENT.PLUS.APPROACH.
EATIT(6)		Array for character strings in earthwork and drainage codes.
EMATCH	/SCAN2/	Equivalenced to ENTITY (20).
ENTITY(20)	/SCAN2/	Alphanumeric characters returned by PARSE from the program input.
EPO	/DRNBLK2/	Effective porosity for drainage analysis.
ESC	/COND/	ESCALATION.RATE.
FAC	/LCY/	NA
FACTOR	/RL1/	GEOGRAPHIC.FACTOR.
FACTR1	/PRVNT/	Cost/sy for SEAL,JOINTS,CRACKS RIGIDPAVEMENT.

Variable	Location	Usage
FACTR2	/PRVNT/	Cost/sy for CLEANING.SWEEPING. RIGIDPAVEMENT
FACTR3	/PRVNT/	Cost/sy/inch for REPLACE. SLABS. RIGIDPAVEMENT.
FDE	/BSBLK/	Estimate of frost penetration in inches, from FROST.DESIGN READ.
FILCSTO	/DRNBLK2/	Filter material cost/cy.
FLEX		Character string for the term flexible.
FLEXVAL		T.V.
FRSTSL	/PRVNT/	NA
GBM	/BSBLK/	GRANULAR.BASE.MATERIAL 1=WELL.GRADED.CRUSHED.MATERIAL 2=NATURAL.SAND.AND.GRAVEL.
GLIST(4,8)		Character array for labeling successive segments of cost curves.
HBOND (3)		Character array for BONDING option 1=PARTIAL 2=UNBONDED 3=BOTH.
HCALC		Character string for CALCULATE.
HCF		Character string for COMPLETE.FAILURE option of CONDITION.
HDRY		Character string for DRY option of CLIMATE.
HFPM(4)		Array containing the character strings identifying different layers of FLEXIBLE.PAVEMENT.MATERIAL.PROPERTIES.
HGC		Character string for GOOD.CONDITION option of CONDITION.
HH(10)	/HBLK/	Thickness array for rigid pavement. HH(1) and HH(10) are

Variable	Location	Usage
		the respective minimum and maximum thickness input by RANGE.OF.THICKNESS.
HIF		Character string for INITIAL.FAILURE option of CONDITION.
HLIST(3,32)		Character array for labeling pavement layers.
HNO		Character string for NO.
HNONE		Character string for NONE.
HNORM		Character string for NORMAL option of CLIMATE.
HREAD		Character string for READ.
HSAG		Character string for NATURAL.SAND AND.GRAVEL.
HSS		Character string for SHATTERED.SLAB option of CONDITION.
H30	/DRNBLK2/	Height of cross slope in feet for drainage analysis.
I		T.V.
IAVAL		Represents the characters FI, which is the boundary between ALIST and BLIST.
IBN	/AMBLK/	Code for BONDING option 1=PARTIAL 2=UNBONDED 3=BOTH. (Note: in CKDATA this code is increased by one.)
IBTE	/BSBLK/	Index for BASE.TRADEOFF and FROST.DESIGN

IBTE	BASE.TRADEOFF	FROST.DESIGN
1	NO	NO or READ
2	unused	
3	TRADEOFF	NO

Variable	Location	Usage
		4 TRADEOFF READ 5 TRADEOFF CALCULATE 6 NO CALCULATE
IBVAL		Represents the characters RI which is the boundary between BLIST and CLIST.
IC		Index for CONDITION 1=GOOD.CONDITION 2=INITIAL.FAILURE 3=SHATTERED.SLAB 4=COMPLETE.FAILURE.
ICYCLE		Time interval between applications of SEAL.JOINTS.CRACKS.RIGIDPAVEMENT.
ID	/DOBK/	Index for CALCULATION TYPE 1=MAINTENANCE 2=LIFE.CYCLE 3=DESIGN.
IDF	/RODLOD/	DESIGN.INDEX.FLEXIBLE.
IDGWTO	/DRNBLK2/	Depth to ground water table in feet for drainage analysis.
IDIPO	/DRNBLK2/	User input depth to pipe in feet for drainage analysis.
IDR	/RODLOD/	DESIGN.INDEX.RIGID.
IDRY	/SUBK/	Index for CLIMATE 1=NORMAL 2=DRY.
IFCON	/FCON/	Index for INITIAL.FAILURE 1=NO 2=YES.
IFD		T.V. for FROST.DESIGN.
IFL	/PRVNT/	Number of cost pairs input for OTHER.REPAIRS.FLEXIBLE.PAVEMENT.
ILOC		Index for locating list variables.

Variable	Location	Usage
IMAN	/RDSTR/	NA
IMIX	/MIXBLK/	Total number of input VEHICLE. TYPE.
IO	/SCAN2/	Variable for tape number.
IREST	/RESTR/	Index for DESIGN.RESTRICTION 1=NONE 2=RIGID 3=FLEXIBLE.
IRG	/PRVNT/	Number of cost pairs of OTHER.REPAIRS.RIGIDPAVEMENT.
ISKIP	/PRVNT1/	Index for MAINTENANCE.COST.ANALYSIS 1=NO 2=YES.
ISKP		T.V.
ITY	/DOBK/	Index for DTYPE 1=RIGID 2=FLEXIBLE.
IUBC	/SUBK/	Index for cohesion and frost susceptibility (FS) 1=COHESIONLESS NFS 2=COHESIVE NFS 3=COHESIONLESS FS 4=COHESIVE FS.
IVALUE	/SCAN2/	Integer value returned by PARSE, equivalenced to VALUE.
IVM	/PRVNT1/	Indicates inclusion of VEHICLE. MAINTENANCE when set equal to 1.
I1		T.V.
I2		T.V.
I3		T.V.
I4		T.V.

Variable	Location	Usage
I5		T.V.
J		T.V
JCYCLE	/PRVNT/	Time interval between occurrences of MAINTAIN.DRAINS.
JDL	/SCAN3/	DESIGN.LIFE.
JISKIP	/PRVNT1/	Indicates inclusion of ROUTINE. MAINTENANCE when equal to 1.
JMAN	/MANLK/	Index for GENERATE.MATERIAL. COMBINATIONS 1=YES 2=NO.
JREST	/RESTR/	Index for OVERLAY.RESTRICTION 1=NONE 2=RIGID 3=FLEXIBLE.
JXX(20,20)	/MANLK/	Array containing SUBBASE.TYPES JXX(I, J) where: I is a scheme number and J corresponds to subbases in scheme 1.
K		T.V.
K2		T.V.
K4	/RL1/	NA
K7	/RL1/	Number of lines in GENERAL.DESCRIPTION.
LENGTHO	/DRNBLK2/	Longitudinal length in feet for drainage analysis.
LFUNC	/TYPBK/	Index for TRAFFIC.AREA for airfields or CLASS.OF.ROAD 1=A 3=C 5=E 2=B 4=D 6=F.

Variable	Location	Usage
LMH	/TYPBK/	Index for LOAD.CATEGORY 1=LIGHT 2=MEDIUM 3=HEAVY.
LOUTO	/DRNBLK2/	Average length of outlet pipe in feet for drainage analysis.
LS	/LCY/	Number of years specified by the TIMES input at which thickness calculations are to be made.
LZ	/RODLOD/	Indicates a roadway analysis when equal to 3.
MATCH	/SCAN2/	Equivalenced to ENTITY(I)
MLYST	/MANLK/	NUMBER.OF.SUBBASE.SCHEMES.
MODE	/SCAN2/	Returned by PARSE; indicates the type of ENTITY. See PARSE in the SCAN package for a more detailed description. 1-integer 5-anytext 2-real 6-separator 3-label 7-string 4-name 8-end of getstr mode 9-end of record.
MXN	/AMBLK/	NA
NB	/LYTD/	Number of base layers.
NCHAR	/SCAN2/	Number of characters in ENTITY; returned by PARSE.
NCOM	/LYTD/	Number of compacted subgrade layers.
NERR	/SCAN2/	Number of input errors.
NFL	/PRVNT/	Time interval between occurrences of OTHER.MAINTENANCE. FLEXIBLE.PAVEMENT.
NFLEX	/TYP/	NA

Variable	Location	Usage
NLIST	/SCAN2/	Number of members of ALIST, BLIST, and CLIST (equal to 30 in current program version).
NNAT	/LYTD/	Number of natural subgrade layers.
NOACFT(50,10)	/RLMN/	Passes/year/vehicle; for airfields NOACFT (IJ), passes in year I for aircraft J; for roads, when J=1, passes in year I for rigid design; and when J=2, passes in year I for flexible design (vehicle is always the same).
NOD	/NBLK/	NA
NOG	/NBLK/	NA
NOH	/NBLK/	NA
NOO(10)	/RDSTR/	Number of overlays in each strategy.
NOSG	/NBLK/	NA
NOUTO	/DRNBLK2/	Outlet code for drainage 0=outlets not considered 1=outlets drain to one side 2=outlets drain to both sides.
NP	/SCAN3/	Code for WANDER 1=CHANNELIZED 2=UNCHANNELIZED.
NPT	/NBLK	NA
NR	/SCAN2/	T.V.
NRG	/PRVNT/	Interval in years between the activity OTHER.MAINTENANCE.RIGID-PAVEMENT.
NRIGID	/TYP/	Code for RIGID.STRUCTURAL.ANALYSIS 1=CALCULATE 2=READ.

Variable	Location	Usage
NSBB	/LYTD/	Number of subbase layers.
NSGY		T.V.
NUMS	/RDSTR/	Number of overlay strategies being considered.
NW		Number of 4-character groups in ENTITY, (NCHAR+3)/4 (see PARSE in SCAN PACKAGE for definition of ENTITY).
NX	/NBLK/	NA
NY	/NBLK/	NA
NYOO(20)	/MANLK/	NYOO(I) is number of subbases in scheme I.
OMTF	/MTO/	MINIMUM.THICKNESS.FLEXIBLE. OVERLAY.
OMTR	/MTO/	MINIMUM.THICKNESS.RIGID. OVERLAY.
PERMO	/DRNBLK2/	Permeability in fpm for drainage.
PIPCSTO	/DRNBLK2/	Cost of pipe per lineal foot for drainage.
PTCH	/PRVNT/	Cost/sy for PATCHING.FLEXIBLE. PAVEMENT.
RDCD1(10)		Array of coverage levels for each design index in rigid design, as listed in TR-4-18 (See Section References).
RDLD2(10)		Array of coverage levels for each design index in flexible design, as listed in TR 5-75-10 (See Section References).
REPFL(10,2)	/PRVNT/	Array for OTHER.REPAIRS FLEXIBLE.PAVEMENT, where REPFL(I,1)

Variable	Location	Usage
		is the year, and REPFL(I,2) is the cost for that year.
REPRG(10,2)	/PRVNT/	Similar to REPFL, except for OTHER.REPAIRS.RIGIDPAVEMENT.
RIGI		Character string for RIGID.
RLIST(4)		Character array for pavement systems in ROUTINEMAINTENACE (i.e., RIC, ROS, FIC FOS).
RNO	/DRNBLK2/	Manning roughness factor for drainage.
SCHE		Character string for SCHEME.
SCLPOP	/PRVNT/	Cost/sy for REPAIR.SCALING. POPOUTS.RIGIDPAVEMENT.
SION	/SCAN2/	Character string for COHESIONLESS.
SIVE.	/SCAN2/	Character string for COHESIVE.
SLCT	/PRVNT/	Cost/sy for SURFACE.TREATMENT. FLEXIBLE.PAVEMENT.
SLO	/DRNBLK2/	Longitudinal slope for drainage.
STORE1(10,10)	/MIXBLK/	Array of CONCRETE.STRESSES. ON.GRADE for each vehicle.
STORE2(10,10)	/MIXBLK/	Array of CONCRETE.STRESSES.OVER. ASPHALT for each vehicle.
STRA		Character string for STRATEGY.
SUBD	/SUBK/	SUBGRADE.DENSITY as a percentage of maximum dry density.
TA(6)		Character array of letters A through F used in TRAFFIC.AREA and CLASS. OF.ROAD.
TC(3)		Character array for LOAD.CATEGORY.

Variable	Location	Usage
TCY(50)	/SCAN3/	NA
TM(20)	/HBLK/	Array containing the specific years at which pavement thickness calculations are to be made.
TOL	/BSBLK/	NA
TRL(10)	/SCAN3/	PAST.TRAFFIC for each vehicle.
TRST	/DMBLK/	Economic factor which combines DISCOUNT and ESCALATION.RATE.
TRY(20)	/LCY/	NA
UNCH		Character string for UNCHANNELIZED.
VALUE	/SCAN2/	Real value returned by PARSE. equivalenced to IVALUE.
WGCM		Character string for WELL.GRADED. CRUSHED.MATERIAL.
WOS	/SA/	WIDTH.OF.SECTION in feet.
XCBR	/LCY/	SUBGRADE.CBR.
XK	/NBLK/	SUBGRADE.MODULUS, in pci.
XMT(10,6)	/LYTD/	Array containing characteristics of up to ten possible subbase layers where: XMT (I,1) is the CBR of layer I, XMT (I,2) is the density, XMT (I,3) is unused, and SMT (I,4) is the IUBC (cohesion, frost susceptibility) code.
XSTR	/LCY/	CONCRETE.FLEXURAL.STRENGTH in psi.
YCBR(10,6)	/LYTD/	Array containing characteristics of up to 10 possible natural subgrade layers where: YCBR (I,1) is the CBR of layer I, YCBR (I,2) is the density,

Variable	Location	Usage
		YCBR (I,3) is the layer thickness, and YCBR (I,4) is the IUBC code.
YES		Character string for YES.
YK	/LCY/	NA
ZCBR(10,6)	/LYTD/	Array containing characteristics of up to 10 possible compacted subgrade layers where: ZCBR (I,1) is the CBR of layer I, ZCBR (I,2) is the density, ZCBR (I,3) is unused, and ZCBR (I,4) is the IUBC code.
ZMT(3,4)	/LYTD/	Array containing the CBR values for up to three base materials where ZMT (I,1) is the CBR of layer I.

Common Blocks

Common blocks contained in PACKET are:

AMBLK, ARBK, BLBK, BSBLK, COND, CSTBK, CUSR, DMBLK, DOBK, DOM, DRNBLK, DRNBLK2, FCON, HBLK, KAYBK, LCY, LYTD, MANLK, MIXBLK, MTO, MXBLK, NBLK, PRVNT, PRVNT1, RDSTR, RESTR, RLMN, RL1, RL2, RODLOD, SA, SCAN2, SCAN3, SUBK, SZBK, TYP, TYPBK.

Tapes

The tapes used by PACKET are:

TAPE 2 -- ENDFILE is written and the tape is rewound.
TAPE 12 -- DRAINAGE analysis output is started with drainage input listing.
TAPE(IO)-- Defined as TAPE8, echo prints LIFE2 input data and error messages.

Traceback

PROGRAM PACKET is called as part of OVERLAY (1,0) by MAIN and calls CKDATA CTABLE, PARSE, PLABAY, RDLINE, and the inline function FLOAT.

Illustrations

None.

References

W. N. Brabston, et al., *Development of a Structural Design Procedure for All-Bituminous Concrete Pavements for Military Roads*, Technical Report S-75-10 (Waterways Experiment Station, 1975).

P. F. Carlton, *Development of Rigid Pavement Thickness Requirements for Military Roads and Streets*, Technical Report 4-18 (Ohio River Division Laboratories, 1961).

MDATA

Purpose

MDATA initializes variables for OVERLAY (1,0) through the use of DATA statements.

Formal Parameters

Since MDATA has no formal parameters, the header card appears as follows:

BLOCK DATA MDATA

Description

MDATA is a block data routine. As such, it contains common blocks and data statements, but no executable statements. All of the variables in MDATA are initialized when OVERLAY (1,0) is loaded.

Variables

The arrays containing the symbols for the input variables ALIST, BLIST, and CLIST are defined in MDATA. Other counters and indices are also given values by this routine. However, since no calcuations or manipulations occur, (i.e., no executable statements), individual variable descriptions are left to the routines where these variables are used.

Common Blocks

The common blocks for MDATA are PARS and SCAN2.

Tapes

None.

Traceback

Since this is BLOCK DATA, no calls in any direction occur; the data is automatically given values, after the overlay is loaded in computer memory.

Illustrations

None.

References

None.

AD-A067 691 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAI--ETC F/G 13/2
SYSTEMS APPROACH TO LIFE-CYCLE DESIGN OF PAVEMENTS. VOLUME II. --ETC(U)
JAN 79 E S LINDOW

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2 OF 5

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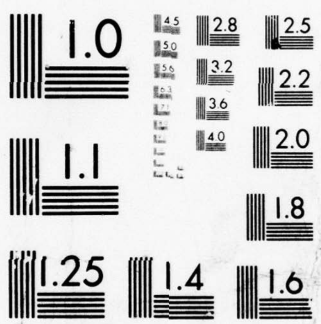

MICROCOPY RESOLUTION TEST CHART

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CKDATA

Purpose

CKDATA checks all data options for verification of input data.

Formal Parameters

Since CKDATA has no formal parameters, the header card appears as follows:

SUBROUTINE CKDATA.

Description

CKDATA determines what input will be required for the run based on the following variables: CALCULATION.TYPE, ROUTINE.MAINTENANCE, DESIGN.RESTRICTION, OVERLAY.RESTRICTION, RIGID.ON.FLEX, BONDING, GENERATE.STRATEGIES, BASE.TRADEOFF, FROST.DESIGN, FLEXIBLE.STRENGTH.ANALYSIS, RIGID.STRUCTURAL.ANALYSIS, GENERATE.MATERIAL.COMBINATIONS. If the values are required, their corresponding LLIST value [LLISTA(I), LLISTB(I), LLISTC(I)] will be assigned the logical value TRUE.

A DO loop checks these arrays for TRUE, and then the corresponding DATA value [ICHECK(I), JCHECK(I), KCHECK(I)] is used in a computer GO TO statement to signal that a check will be performed on related variables. This is done for each array -- LLISTA(I), LLISTB(I), and LLISTC(I). If any errors are found, the program prints an error message and checks the remaining input for errors before stopping.

If no errors are found, the program returns to PACKET, and the run continues. Figure B1 illustrates details on all of the data checks performed by CKDATA.

Variables

Variable	Location	Usage
AHH(10)	/MBLK/	NA
ALIST(30)	/SCAN2/	Array containing symbols for input variables (A-FDE).
ALOS	/SA/	LENGTH.OF.SECTION (feet).
AREA	/ARBK/	Pavement area in square yards from (ALOS*WOS)/9.0.

Variable	Location	Usage
AXK	/LCY/	NA
BLIST(30)	/SCAN2/	Array containing symbols for input variables (FO-RETU).
BTE	/BSBLK/	Base thickness estimate.
CCCST(50,10,2)	/CSTBK/	Array for cost curve data, where CCCST(I,1,1) is the number of curve segments for variable I; CCCST(I,J,1) is the value on the abscissa for the (J-1) cost data pair; CCCST(I,J,2) is the value on the ordinate for the (J-1) cost data pair (i.e., the cost).
CLIST(30)	/SCAN2/	Array containing symbols for input variables (RM-Z).
COVRGD(10,20)	/MIXBLK/	NA
CSTRT(10,6)	/RDSTR/	Array containing TIMES.OF OVERLAYS; CSTRT(I,J), where I is the strategy number, and J is the index for the year of overlay placement.
DLCF	/CUSR/	Cost for delays due to construction of a flexible overlay.
DLCR	/CUSR/	Cost for delays due to construction of a rigid overlay.
DT	/DOBK/	Value of DTHICKNESS for existing pavement (total thickness for flexible, slab thickness for rigid).
DT2Q	/DOBK/	NA
EARTHWK	/RL1/	NA
ENTITY(20)	/SCAN2/	NA
FAC	/LCY/	NA
FACTOR	/RL1/	NA

Variable	Location	Usage
FDE	/BSBLK/	Estimate of required depth of frost protection (inches) for FROST.DESIGN.
GBM	/BSBLK/	GRANULAR.BASE.MATERIAL 1=WELL.GRADED.CRUSHED.MATERIAL 1=NATURAL.SAND.AND.GRAVEL.
HH(10)	/MBLK/	Thickness array for rigid pavements. HH(1) and HH(10) are the minimum and maximum thicknesses respectively, which are input by RANGE.OF.THICKNESS.
I		T.V.
IAXK	/KAYBK/	Unused variable stipulating allowance of rigid overlay on asphalt; internally set to allow this arrangement (equal to 1).
IBN	/AMBLK/	Index identifying rigid pavement bonding: 1=PARTIAL 2=UNBONDED 3=BOTH.
IBTE	/BSBLK/	Index for BASE.TRADEOFF and FROST.DESIGN.

IBTEE	BASE.TRADEOFF	FROST.DESIGN
1	NO	NO or READ
2	unused	
3	TRADEOFF	NO
4	TRADEOFF	READ
5	TRADEOFF	CALCULATE
6	NO	CALCULATE

Variable	Location	Usage
ICBR	/MXBLK/	NA
ICCSIZ		Counter (NCOM+NSBB+NB+12).
ICHECK(30)		Array containing index number assigned to LLISTA(30) and used for checking TRUE.
ICOUNT	/RESTR/	NA

Variable	Location	Usage
ID	/DOBK/	Index for CALCULATION TYPE 1=MAINTENANCE 2=LIFE.CYCLE 3=DESIGN.
IDENT(3)	/RL1/	NA
IDF	/RODLOD/	NA
IDR	/RODLOD/	NA
IDRY	/SUBK/	Index for CLIMATE 1=NORMAL 1=DRY.
IFCON	/FCON/	Index for INITIAL.FAILURE 1=NO 2=YES.
IGINT	/MXBLK/	NA
IHA		T.V.
IMAN	/RDSTR/	Unused index for GENERATE. STRATEGIES; internally set to 2 (NO).
IMIX	/MIXBLK/	Number of VEHICLE.TYPE in the input.
IO	/SCAN2/	Variable for tape number.
IP1		T.V.
IP10		T.V.
IP11		T.V.
IP12		T.V.
IP2		T.V.
IP3		T.V.
IP4		T.V.

Variable	Location	Usage
IP5(10)		T.V.
IP6		T.V.
IP7		T.V.
IP9		T.V.
IREST	/RESTR/	Index for DESIGN.RESTRICTION 1=NONE 2=RIGID 3=FLEXIBLE.
ISKIP	/PRVNT1/	Index for MAINTENANCE.COST. ANALYSIS 1=NO 2=YES.
ITY	/DOBK/	Index for DTYPE 1=RIGID 2=FLEXIBLE.
IUBC	/SUBK/	Index for frost susceptibilty (FS) and cohesion 1=cohesionless, NFS 2=cohesive, NFS 3=cohesionless, FS 4=cohesive, FS.
J		T.V.
JCHECK(30)		Array containing index number assigned to LLISTB and used for checking TRUE.
JDL	/SCAN3/	DESIGN.LIFE of the pavement in years.
JINDEX		T.V. (for ICHECK JCHECK KCHECK arrays).
JISKIP	/PRVNT1/	Indicates inclusion of ROUTINE. MAINTENANCE when equal to 1.
JJ	/MIXBLK/	NA

Variable	Location	Usage
JMAN	/MANLK/	Index for GENERATE.MATERIAL. COMBINATIONS 1=YES 2=NO.
JMIX		Corresponds to total number of VEHICLE.TYPE in the input.
JREST	/RESTR/	Index for OVERLAY.RESTRICTION 1=NONE 2=RIGID 3=FLEXIBLE.
JTYPE(3,10)	/RLMN/	Character array for VEHICLE. TYPE.
JXX(20,20)	/MANLK/	Array containing SUBBASE.TYPES JXX(I,J) where I is the scheme number, and J corresponds to subbases in scheme I.
K		T.V.
KCHECK(30)		Array containing index number assigned to LLISTC and used for checking TRUE.
K4	/RL1/	Number of construction schemes to be evaluated.
K7	/RL1/	NA
L		T.V.
LFUNC	/TYPBK/	Index for TRAFFIC.AREA or CLASS.OF.ROAD 1=A 3=C 5=E 2=B 4=D 6=F.
LG1		TV (logical).
LLISTA(30)		Logical array set to TRUE if variable values in ALIST are required by program.

Variable	Location	Usage
LLISTB(30)		Logical array set to TRUE if variable values in BLIST are required by program.
LLISTC(30)		Logical array set to TRUE if variable values in CLIST are required by program.
LMH	/TYPBK/	Index for LOAD.CATEGORY 1=LIGHT 2=MEDIUM 3=HEAVY.
LR	/MIXBLK/	NA
LS	/LCY/	Number of years, specified by TIMES input, in which thickness calculations are to be made.
LZ	/RODLOD/	Indicates a roadway analysis when equal to 3.
M		T.V.
MLYST	/MANLK/	NUMBER.OF.SUBBASE.SCHEMES.
MNT	/DOM/	
MODE	/SCAN2/	NA
MXN	/AMBLK/	Maximum number of overlays.
NB	/LYTD/	Number of base layers.
NCHAR	/SCAN2/	NA
NCOM	/LYTD/	Number of compacted layers.
NFLEX	/TYP/	Set equal to 0 if DESIGN. RESTRICTION and OVERLAY.RESTRICTION are RIGID.
NLIST	/SCANZ/	NA
NNAT	/LYTD/	Number of natural layers.

Variable	Location	Usage
NOACFT(50,10)	/RLMN/	Passes/year/vehicle; for airfields NOACFT(IJ) is passes in year I for aircraft J; in roads NOACFT(IJ) is passes in year I for rigid design when J=1 and for flexible design when J=2 (vehicle does not change).
NOD	/NBLK/	NA
NOFSG		T.V.
NOG	/NBLK/	NA
NOH	/NBLK/	Number of thicknesses in array HH
NOO(10)	/RDSTR/	Number of overlays in each strategy.
NOOO		T.V. for NYOO(I).
NOPTS		Number of coordinates of input cost data including CCCST(I1,1).
NOSG	/NBLK/	NA
NP	/SCAN3/	NA
NPT	/NBLK/	NA
NR	/SCAN2/	NA
NRIGID	/TYP/	Code for RIGID.STRUCTURAL. ANALYSIS: 1=CALCULATE, 2=READ. Set to 0 if DESIGN.RESTRICTION and OVERLAY.RESTRICTION are both FLEXIBLE.
NSBB	/LYTD/	Number of subbase layers.
NUMO		T.V. for NOO(I).
NUMS	/RDSTR/	Number of strategies.
NX	/NBLK/	NA

Variable	Location	Usage
NY	/NBLK/	NA
NY00(20)	/MANLK/	Number of subbases in scheme I.
N1		T.V. (DRAI).
N10		Error counter.
N2		T.V. (DRAI).
N3		T.V. (CSOA, CSOG, FO, FP, FPB, RM).
N4		T.V. (FPB, RM).
N5		T.V. (RM, ST).
N6		T.V. (RM, ST).
N7		T.V. (RM).
N8		T.V. (RM, YT).
N9(4)		T.V. (RM).
P8(10)		Temporary array for CSTRI(IJ).
REVERSE		T.V. (ROT).
RLIST(4)		Character array for ROUTINE. MAINTENANCE analysis where 1=RIC (rigid initial construction) 2=ROS (rigid overlay system) 3=FIC (flexible initial construction) 4=FOS (flexible overlay system).
STORE1(10,10)	/MIXBLK/	Array of CONCRETE.STRESSES. ON.GRADE where I is the vehicle type, and J is the thickness.
STORE2(10,10)	/MIXBLK/	Array of CONCRETE.STRESSES. OVER.ASPHALT, where I is the vehicle type, and J is the thickness.

Variable	Location	Usage
SUBD	/SUBK/	SUBGRADE.DENSITY as a percentage of maximum dry density.
TCY(50)	/SCAN3/	NA
TM(20)	/MBLK/	Array containing the years at which pavement thickness calculations are to be made.
TRL(10)	/SCAN3/	NA
TRY(20)	/LCY/	NA
VALUE	/SCAN2/	NA
WOS	/SA/	WIDTH.OF.SECTION (feet).
X		T.V. (ROT).
XCBR	/LCY/	SUBGRADE.CBR.
XK	/NBLK/	SUBGRADE.MODULUS in pci.
XMT(10,6)	/LYTD/	Array containing characteristics of subbase layers where XMT(I,1) is CBR of layer I, XMT(I,2) is the density, XMT(I,3) is unused, and XMT(I,4) is the IUBC code.
XNOH		T.V. (ROT).
XSTR	/LCY/	CONCRETE.FLEXURAL.STRENGTH in psi.
YCBR(10,4)	/LYTD/	Array containing characteristics of the natural subgrade layers, where YCBR(I,1) is CBR of layer I, YCBR(I,2) is the density, YCBR(I,3) is the layer thickness, and YCBR(I,4) is the IMBC code.
YK	/LCY/	NA
ZCBR(10,6)	/LYTD/	Array containing characteristics of compacted subgrade layers where ZCBR(I,1) is the CBR of layer I,

Variable	Location	Usage
		ZCBR(I,2) is the density, ZCBR(i,4) is unused, and ZCBR(I,4) is the IUBC code.
ZMT(3,4)	/LYTD/	Array containing the base CBR values; ZMT((I,1) is the CBR of layer I.

Common Blocks

The common blocks contained in CKDATA are:

AMBLK, AR, BK, BSBLK, CSTBK, CUSR, DOBK, DOM, FCON, HBLK, KAYBK, LCY, LYTD, MANLK, MIXBLK, MXBLK, NBLK, PRVNT1, RDSTR, RESTR, RLMN, RL1, RODLOD, SA, SCAN2, SCAN3, SUBK, TYP, TYPBK.

Tapes

The tapes used in CKDATA are:
TAPE6 -- writes values of variables;
TAPE(IO) -- writes error messages to the user.

Traceback

SUBROUTINE CKDATA is called by PACKET.

Illustrations

Figure B1 is a descriptive flowchart of SUBROUTINE CKDATA.

References

None.

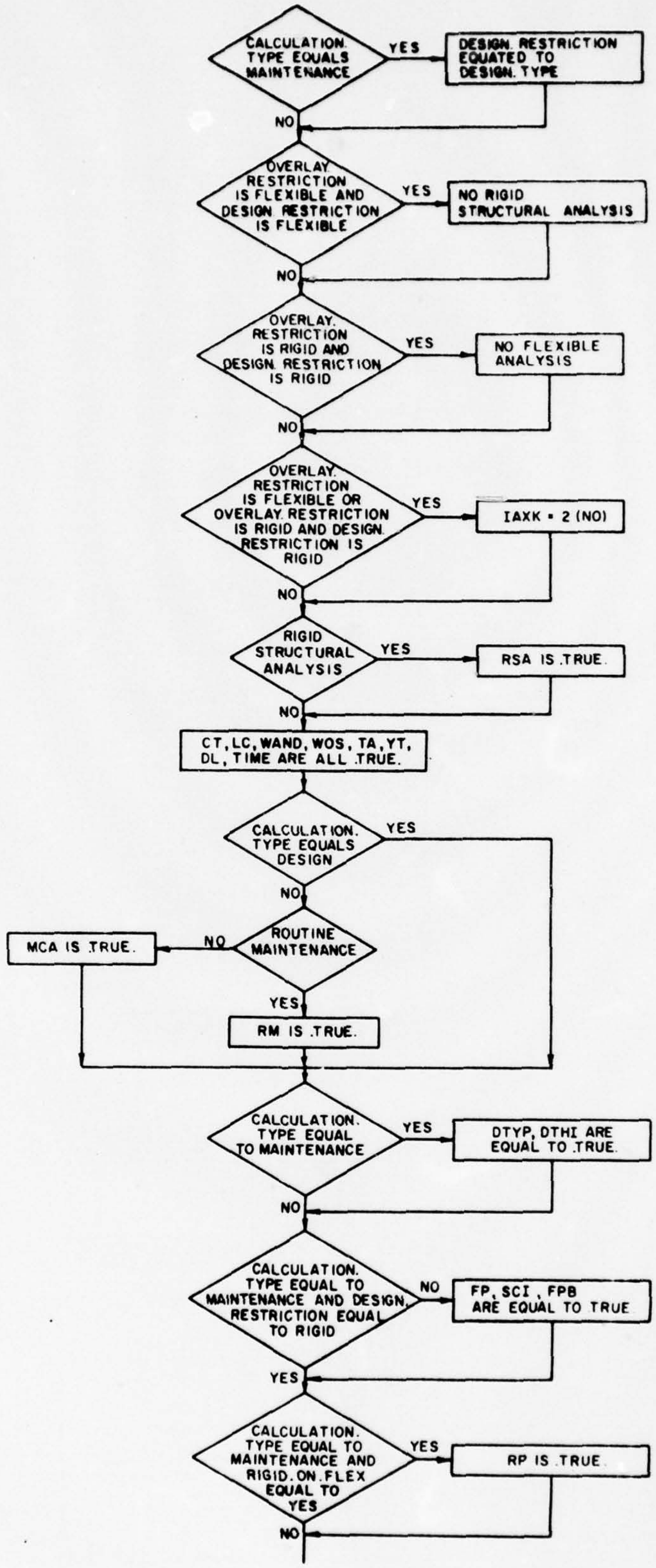


Figure B1. Subroutine CKDATA flowchart..

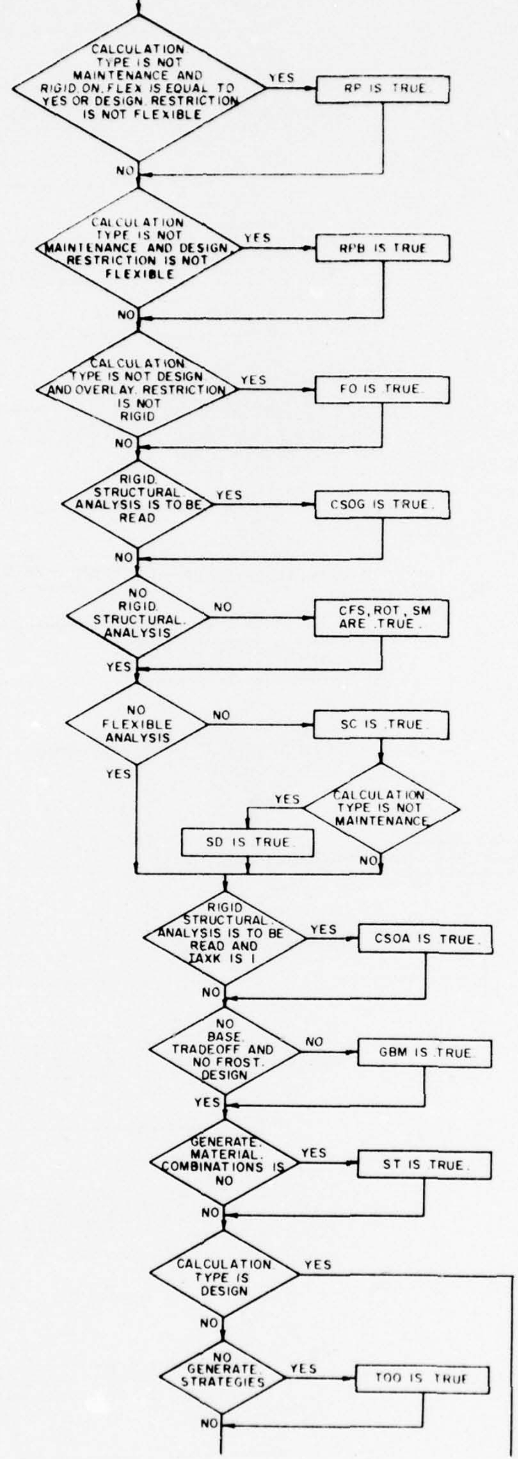


Figure B1 (cont'd).

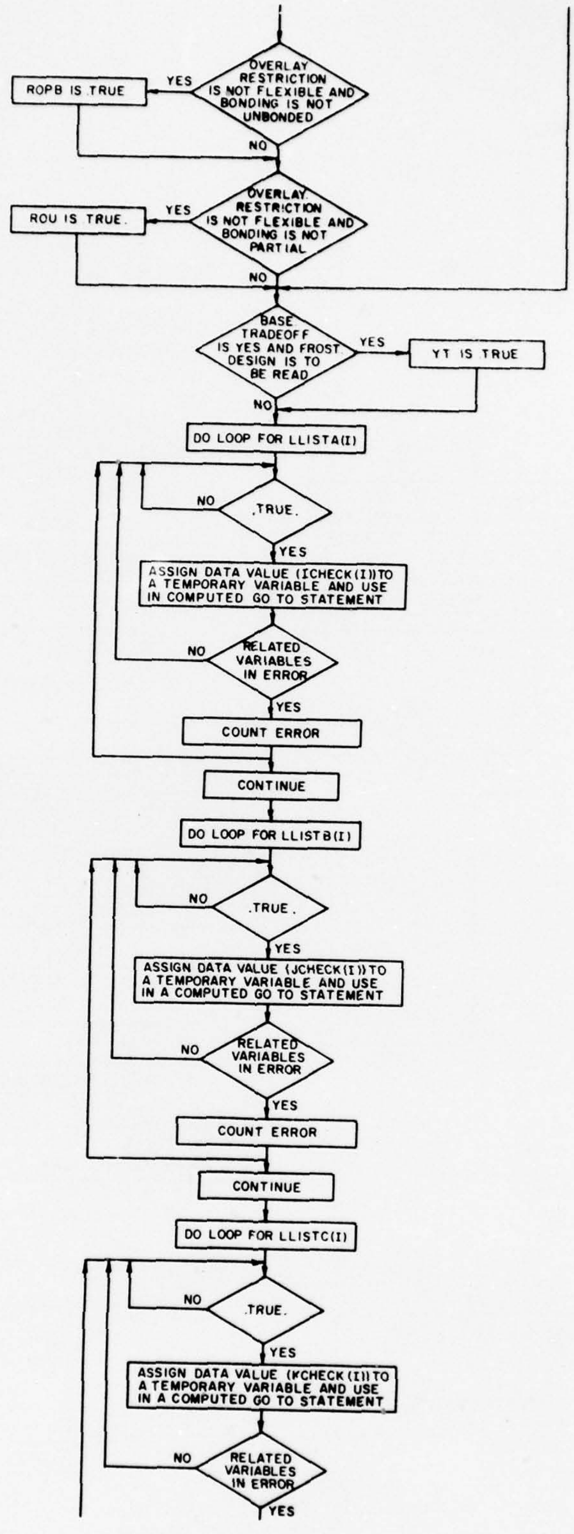


Figure B1.(cont'd).

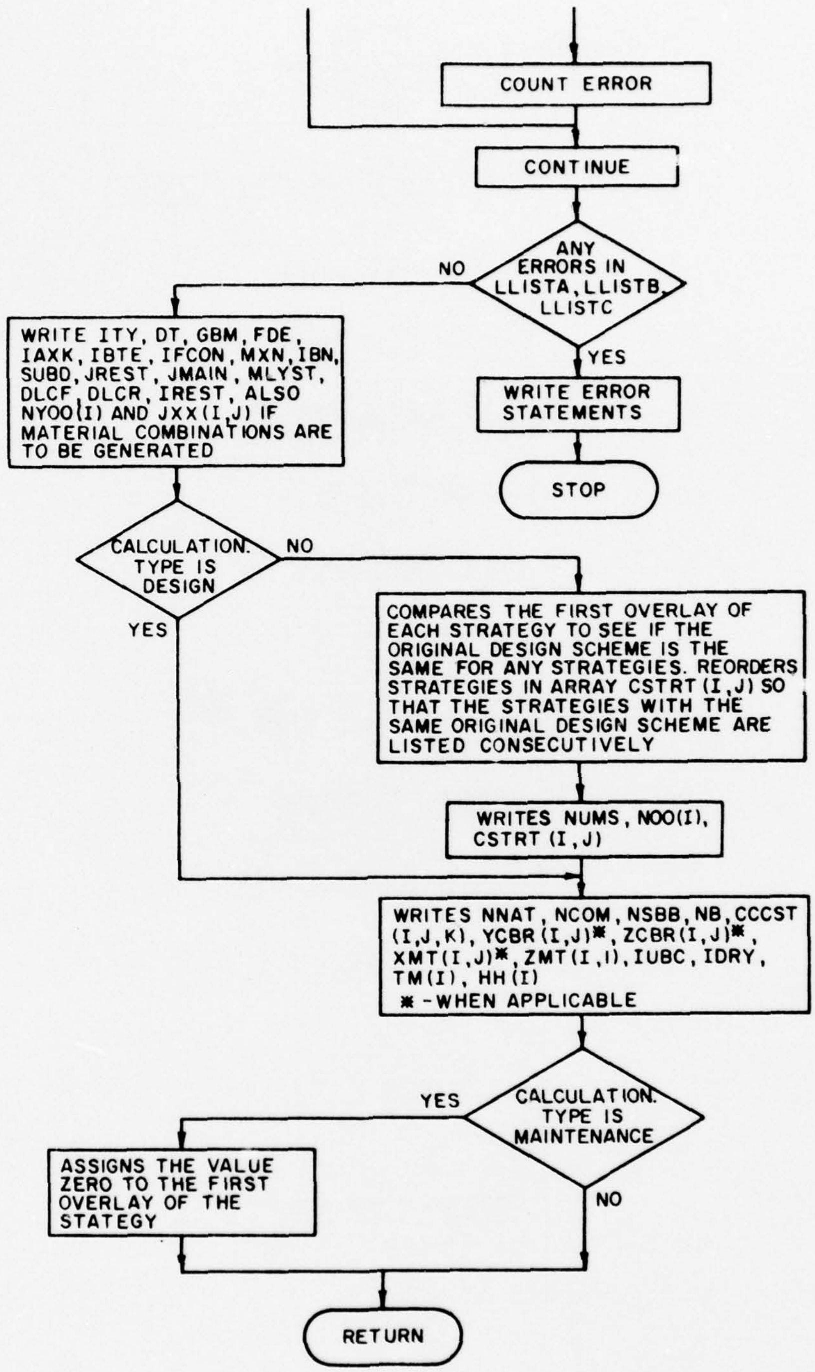


Figure B1 (Cont'd).

PLABAY

Purpose

PLABAY checks for errors in data required for FLEXIBLE.PAVEMENT.MATERIAL.PROPERTIES and then loads this data into an array.

Formal Parameters

The header card for PLABAY appears as follows:

SUBROUTINE PLABAY (NM,B,NQ).

Description

PLABAY is an error check routine for information required of FLEXIBLE. PAVEMENT.MATERIAL.PROPERTIES. The properties checked are:

1. SUBGRADE (CBR, density, thickness, cohesion, frost susceptibility)
2. COMPACTED (CBR, density, cohesion, frost susceptibility)
3. SUBBASE (CBR, density, cohesion, frost susceptibility).

PLABAY loads this information into the array B(I,J), which is returned to PACKET. Since several materials are possible in each layer (i.e., subgrade, compacted, subbase), the error check is performed for each material with variable NR determining the material, and NM determining the layer.

Variables

Variable	Location	Usage
ALIST(30)	/SCAN2/	NA
B(10,4)	FP	Array B(I,J) contains information for material I as follows: CBR when J=1 Density when J=2 Thickness (SUBGRADE only) when J=3 Variable IUBC code when J=4, where 1 is COHESIONLESS, nonfrost susceptible (NFS) 2 is COHESVE, NFS 3 is COHESIONLESS, frost susceptible (FS) 4 is COHESIVE FS.

Variable	Location	Usage
BLIST(30)	/SCAN2/	NA
CLIST(30)	/SCAN2/	NA
ENTITY(20)	/SCAN2/	Alphanumeric copy of an ENTITY; four characters long.
I		T.V.
IC		T.V.
IO	/SCAN2/	Tape number for WRITE statements.
IVALUE	/SCAN2/	Value of ENTITY (equivalenced to VALUE).
J		T.V.
MODE	/SCAN2/	Returned by PARSE. This indicates the type of ENTITY. (See PARSE in SCAN package for a more detailed explanation.) 1-integer 4-name 7-string 2-real 5-anytext 8-end of getstr mode 3-lable 6-separation 9-end of record.
NCHAR	/SCAN2/	Number of characters in ENTITY.
NLIST	/SCAN2/	NA
NM	FP	Variable indicating the layer under consideration 1=SUBGRADE 2=COMPACTED 3=SUBBASE.
NQ	FP	Material number in a layer; eventually equals the total number of input materials for that layer.
NR	/SCAN2/	Identifying number of the material from the input card.

Variable	Location	Usage
SION	/SCAN2/	Character string SION; indicates COHESIONLESS material.
SIVE	/SCAN2/	Character string SIVE; indicates a COHESIVE material.
VALUE	/SCAN2/	Real value of ENTITY (if it is numeric) equivalenced to IVALUE.

Common Blocks

The common block contained in PLABAY is SCAN2.

Tapes

The tape used in PLABAY is

TAPE (IO) which writes error messages to the user.

Traceback

PLABAY is called by PACKET and calls PARSE and RDLINE.

Illustrations

None.

References

None.

CTABLE

Purpose

CTABLE reads cost data and assigns it to the general cost array CCCST.

Formal Parameters

The header card for CTABLE appears as follows:

SUBROUTINE CTABLE (I,L).

Description

Cost information is input as data pairs which define cost curves (see Figure B2). PACKET identifies the appropriate input as cost data, assigns I and L indices to identify the proper array locations, and transfers this information to CTABLE. CTABLE loads this data into array CCCST as points defining each segment for the cost curves. Any comments on the input associated with cost data are stored in the array CHAR.

Variables

Variable	Location	Usage
ALIST(30)	/SCAN2/	NA
BLIST(30)	/SCAN2/	NA
CCCST(50,10,2)	/CSTBK/	Cost array loaded by CTABLE where: CCCST(I1,1) is the number of curve segments for variable I; CCCST(IJ1) is the value on the abscissa for the (J-1) cost data pair; CCCST(I,J,2) is the value on the ordinate for the (J-1) cost data pair (i.e., the cost).
CHAR(7,50)	/RL2/	Array for any comment on the cost data card.
CLIST(30)	/SCAN2/	NA
DSCRPT(3,50)	/RL2/	NA

Variable	Location	Usage
ENTITY(20)	/SCAN2/	The alphanumeric copy of the card image; four characters per array member.
I	FP	Index for the cost data in array CCCST. Varies according to amount of data. (See Figure B3).
IDSCRPT(30,10)	/RL2/	NA
IO	/SCAN2/	Tape number for output.
IVALUE	/SCAN2/	Value of ENTITY; Equivalenced to VALUE.
I1		T.V.
J		T.V.
K		T.V.
L	FP	Index of the cost data; fixed location for each particular cost item (See Figure B3).
LOCATE(8)	/RL2/	NA
MODE	/SCAN2/	Returned by PARSE; indicates the type of ENTITY. See PARSE in SCAN package for a detailed explanation. 1-integer 4-none 8-end of getstr mode 2-real 5-anytext 9-end of record. 3-label 6-separation 7-string
NAME(5)	/RL2/	NA
NCHAR	/SCAN2/	Number of characters in ENTITY.
NERR	/SCAN2/	Number of errors.
NLIST	/SCAN2/	NA

Variable	Location	Usage
NR	/SCAN2/	NA
NW		Number of four character segments
SION	/SCAN2/	NA
SIVE	/SCAN2/	NA
VALUE	/SCAN2/	Value of ENTITY; equivalenced to IVALUE.

Common Blocks

The common blocks contained in CTABLE are CSTBK, RL2, and SCAN2.

Tapes

TAPE(10) is used by CTABLE to write error messages to user for input errors.

Traceback

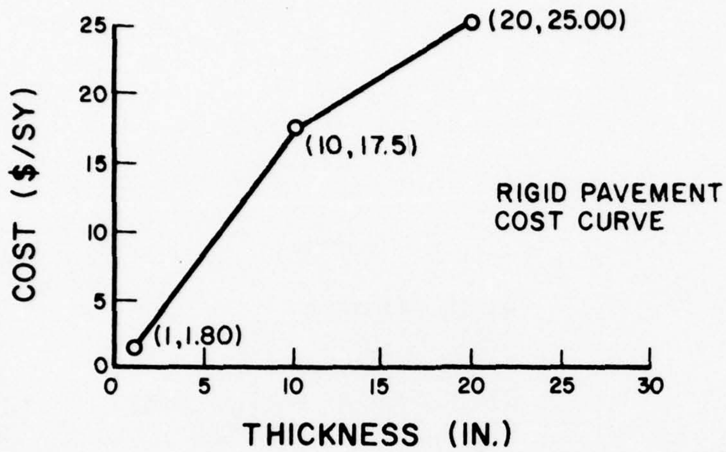
CTABLE is called by PACKET and calls PARSE.

Illustrations

Figure B2 illustrates a typical cost curve which is defined in CTABLE. Figure B3 provides the I and L indices for each of the cost items considered in CTABLE.

References

None.



NOTE: Contents of array CCST(IJK) for RIGID PAVEMENT (I=1, L=17) for the above cost curve:

(1,1,1) = 2 (Number of segments)
(1,1,2) = undefined at this time
(1,2,1) = 1.0
(1,2,2) = 1.80
(1,3,1) = 10.0
(1,3,2) = 17.50
(1,4,1) = 20.0
(1,4,2) = 25.00

Figure B2. Typical cost curve.

I	ITEM	L
1	RIGID.PAVEMENT	17
2	RIGID.PAVEMENT.BASE	18
3	FLEXIBLE.PAVEMENT.BASE	19
5	RIGID.OVERLAY PARTIAL.BOND	21
6	RIGID.OVERLAY UNBONDED	22
7	FLEXIBLE.OVERLAY	23
7 + NCOM	COMPACTED.SUBGRADE	23+NCOM
7 + NCOM + NSBB	SUBBASE	33+NSBB
7 + NCOM + NSBB + NB	FLEXIBLE.PAVEMENT.BASE	43 + NB
10 + NCOM + NSBB + NB	VEHICLE.MAINTENANCE	48
7 + NCOM + NSBB + NB + K	ROUTINE.MAINTENANCE	45 + K

NCOM - number of compacted subgrades
NSBB - number of subbases
NB - number of bases
K - equals 1, 2, 4, 5. For the various types of routine maintenance.

Figure B3. I and L cost indices in CTABLE.

SCAN PACKAGE

Purposes

The SCAN package is composed of several subroutines and is designed to read free-form input data for decoding into program variables.

Formal Parameters

The header cards for the subroutines in the Scan Package are as follows:

```
SUBROUTINE PARSE (ENTITY,MODE,VAL,NCHAR)
SUBROUTINE RDLINE
SUBROUTINE CONCAT (IFROM,LBIT,JTO,MBIT,NBITS)
SUBROUTINE BBRK (IFROM,IB)
SUBROUTINE BACKUP (I).
```

Description

The SCAN package is composed of subroutines PARSE, RDLINE, CONCAT, BBRK, and BACKUP. Since these routines are fully documented in the reference section, only a brief description is given here to provide an understanding of significant operations.

Three variables, initialized in BLOCK DATA MDATA, define parameters available to the SCAN package as follows:

LIMIT---The number of consecutive blanks that cause an END-OF-RECORD to occur.

MARK---The number of columns examined on a card or card image. The remainder of the columns are skipped.

IPRINT---A logical operator that indicates if the LIFE2 input is to be echo printed.

Present values for these parameters are:
LIMIT = 10, MARK = 72, and IPRINT = TRUE.

SUBROUTINE PARSE is used to read and decode LIFE2 input data. Blank and comment cards are ignored. Each time PARSE is called, an entity, mode, value, and length are returned. These parameters are defined as follows.

Entity is an alphanumeric copy of input set off by blanks or separators (eg, comma, quotes). It is a 20 member array, having four characters per member, and is padded with four trailing blanks.

Mode is an integer (1-9) which specifies the type of entity returned by PARSE.

Mode	Type of Entity	Description
1	INTEGER	An integer which may be signed or unsigned however no blanks may be left between sign and digits.
2	REAL	A real number (with decimal point and/or exponential multiplier) which may be signed or unsigned; however, no blanks are permitted within the mantissa or exponent.
3	LABEL	An alphanumeric string without blanks where the first character must be a letter. For example, the entity for the mode 3 input variable DRAINAGE would be DRAI.
4	NAME	An alphanumeric string where the first character must be a letter. The string is separated into groups by periods (e.g., CONCRETE. FLEXURAL.STRENGTH), with the entity becoming the first character of each group (e.g., CFS).
5	ANYTEXT	Specifies text other than a label or name which will be returned in its entirety.
6	SEPARATOR	Returns a separator code in VALUE. This is used internally in SCAN.
7	STRING	Returns as the entity all characters enclosed by quotation marks or

		apostrophes. (For this mode, length [NCHAR] is the number of characters minus quotes or apostrophes.)
8	END OF GETSTR	The closing quotation mark in a string of characters initiates this mode (unused in LIFE2).
9	END OF RECORD	Stipulated when the end of a card is encountered or when a previously defined number of consecutive blanks is encountered. Entity is meaningless in this case.

Value contains the integer (Mode 1) orreal number (Mode 2) for the entity or the separator code (Mode 6). For other modes, VALUE is not used. VALUE is equivalenced to IVALUE, that is, they share the same location (address) in computer memory. This is necessary since PARSE loads both integers and real number in VALUE, with the mode then differentiating between the two when VALUE is assigned to an internal variable.

Length, designated by NCHAR, is the number of characters in the entity minus the padded blanks. Blanks within a string are counted in this length.

Following is an example of an input variable and its interpretation by the SCAN Package.

CONCRETE.FLEXURAL.STRENGTH	650
Entity = CFS	Entity = 650
Mode = 4	Mode = 1
Value = undefined	Value = 650
Length = 3	Length = 3

An option added to PARSE allows for decoding fixed format data for free format variables in three special cases. These cases are required for frost, drainage and earthwork analyses. The entity FROST initiates reading the attached fixed format data onto tape 3 for use in the frost analysis. The entity DRNAGE initiates reading the attached fixed format data onto tape 12 for use in the drainage analysis. Each of the BSTE array members (TL, TD, TDR, PGLEND, APRVN, PGLBRK, APEND, TMP, ELIM, COST, RUN, RC, CD) initiates reading the attached data onto tape 2 for use in the earthwork analysis. Other than these cases, all input is in free format.

SUBROUTINE RDLINE allows data entries to ecompass more than one card. When MODE=9 is encountered (e.g., at the end of a card), RDLINE is called to enable reading of input to progress to the next card. Comment cards are skipped by RDLINE.

CONCAT and BBRK work with PARSE to convert the free form input to a form understandable by PACKET. SUBROUTINE BACKUP reverses the direction of the scan of the input. Although BACKUP is not used at present, it remains for possible later inclusion.

Variables

The variables used in the SCAN subroutines are defined in the sources listed in the reference section. Variables pertinent to understanding the LIFE2 operation have been discussed.

Common Blocks

The common blocks contained in the SCAN subroutines are:

PARSE -- PARS, KARD
RDLINE -- PARS
BACKUP -- PARS
CONCAT -- JP
BBRK -- JP

Tapes

The tapes used in the SCAN package are:

TAPE12 -- receives drainage data
TAPE2 -- receives earthwork data
TAPE3 -- receives frost data
TAPE6 -- writes messages on debug file
TAPE(IO) -- echo prints input data, writes message for end of file encountered on input file.

Tracebacks

PARSE is called by CTABLE, PLABAY, AND PACKET and calls CONCAT, EOF, FLOAT, and MOD.
RDLINE is called by PACKET and PLABAY.
CONCAT is called by PARSE and calls BBRK.
BBRK is called by CONCAT.

Illustrations

None.

References

SCAN User's Manual (University of Illinois, 1970).

APPENDIX C:

OVERLAY (2,0)

OVERLAY (2,0) is a self-contained computer program which has been integrated into the LIFE2 system. As such, the discussion here will present the overlay as a single package. Complete documentation can be found in the reference section of this appendix.

Purpose

OVERLAY (2,0) is an adaptation of the General Dynamics computer program H-51. It is designed to compute concrete stresses for given pavement thicknesses and aircraft gear loads. It is used in LIFE2 only for airfield design.

Formal Parameters

The formal parameters used by the routines in OVERLAY (2,0) are:

PROGRAM LSSP
BLOCK DATA ADATA
SUBROUTINE FINISH
SUBROUTINE GEOM
SUBROUTINE OUTLNE
SUBROUTINE PROBRD
SUBROUTINE CURVE
SUBROUTINE ERN(N1,N2,N3)
SUBROUTINE TABINT(X,Z,Y,NX,NY,TABLE,IND)

Description

OVERLAY (2,0) computes concrete stresses for edge-loaded rigid pavements by using a computerized influence chart. This procedure is based on the theory of a semi-infinite plate on an elastic, dense liquid with a uniformly distributed load applied at an edge.

Through the vehicle data bank (see Appendix J), the user supplies this overlay with the geometric arrangement of wheels in the design landing gear, tire ground pressure, gear load, and other aircraft parameters. The array of pavement thicknesses to be used, H(10), is supplied via common block /HBLK/; traffic area, LFUNC (1-A, 2-B, 3-C, 4-D) by /TYPBK/; and number of thicknesses to be considered and the subgrade modulus of reaction by /NBLK/. Following computations, OVERLAY (2,0)

returns concrete stresses (in psi) for a specific aircraft for various pavement thicknesses (current version uses RANGE.OF.THICKNESS for the maximum and minimum and equally divides the interval to produce a total of ten thicknesses). Thus, for each aircraft in the design traffic, this overlay must be called twice: first for rigid pavement on subgrade, and second for rigid overlay on asphalt.

The results for all thicknesses considered are then placed in STORE1 (10,10) if the pavement is on subgrade (LR=1), or in STORE2 (10,10) if the pavement is on asphalt.

In integrating the original program into the LIFE2 system, subroutine PROBRD was altered to read input from the vehicle data bank and then reduce the gear load by 25 percent; if the traffic area is 'C,' the gear load is further reduced by 25 percent (see Hammitt report listed in reference section).

In addition, program H-51 was modified to allow for the C-5A's unsymmetrical landing gear (see Appendix H). If the user must analyze other unsymmetrical gear, the program can be further modified.

Common Blocks

The common blocks contained in each routine are:

PROGRAM LSSP - ABLK, BBLK, BLK1, DBLK, EBLK, GBLK, HBLK, IBLK, NBLK, PBLK, RBLK, SBLK, XBLK, YBLK

BLOCK DATA ADATA - BLK1, DBLK

SUBROUTINE ERN - None

SUBROUTINE FINISH - ABLK, BBLK, DBLK, EBLK, GBLK, HBLK, IBLK, NBLK, PBLK, RBLK, SBLK, XBLK, YBLK

SUBROUTINE - ABLK, BBLK, BLK1, DBLK, GBLK, HBLK, IBLK, MIXBLK, NBLK, PBLK, RBLK, SBLK, XBLK, YBLK

SUBROUTINE PROBRD - ABLK, BBLK, DBLK, EBLK, GBLK, HBLK, IBLK, NBLK, PBLK, RBLK, TYPBK, XBLK

SUBROUTINE CURVE - ABLK, DBLK, EBLK, GBLK, HBLK, IBLK, NBLK, PBLK, RBLK, XBLK

SUBROUTINE TABINT - None

Tapes

The tapes used in OVERLAY (2,0) are:

TAPE 6 - echo prints the input, writes error messages, and writes output.
TAPE 7 - reads the vehicle data bank for a particular vehicle.

Traceback

LSSP is called as the driver when OVERLAY (2,0) is loaded and calls GEOM, OUTLNE, and PROBRD.

ERN is called by PROBRD.

FINISH is called by OUTLNE.

GEOM is called by LSSP.

OUTLNE is called by LSSP and calls CURVE, FINISH, and TABINT.

PROBRD is called by CSSP and calls ERN.

CURVE is called by OUTLNE.

TABINT is called by OUTLNE.

Illustrations

None.

References

G. M. Hammitt, *Multiple Wheel Heavy Gear Load Pavement Tests,* Vol IV, AFWLTR-70-113 (Air Force Weapons Lab, 1971).

W. C. Kreger, *Computerized Aircraft Ground Flotation Analysis - Edge-Loaded Rigid Pavement,* ERR-FW-572 (General Dynamics Corp., 1967).

G. Pickett and G. K. Ray, *Influence Charts for Concrete Pavements, Transactions ASCE* (1951).

APPENDIX D:

OVERLAY (3,0)

OVERLAY (3,0) formulates rigid and flexible pavement design schemes and produces maintenance strategies for each. When developing the maintenance strategies, the least expensive combination of overlays for each design scheme is saved. The results of frost, earthwork, and drainage analyses are used to establish required thicknesses for each design scheme. The final results from OVERLAY (3,0) are placed on tape 7 for use by OVERLAY (6,0).

PAVE

Purpose

PROGRAM PAVE is the driver for OVERLAY (3,0). This program controls the formulation of the flexible and rigid pavement thickness designs, compares costs, and stores the design combinations.

Formal Parameters

The header card for this program is: PROGRAM PAVE.

Description

PAVE uses three different methods to find the required pavement thicknesses:

1. For rigid airfield pavements, the design factor is used to find coverages to failure. Mixed traffic effects are calculated, and the required thicknesses are determined.

2. For rigid roadway pavements, each 5000 coverage design thickness (calculated in OVERLAY (0,0)) is multiplied by the percentage of design thickness for different years to obtain required thicknesses.

3. Flexible pavements use a load repetitions factor, CBR, and equivalent single-wheel loads to calculate coverages to failure. Mixed traffic is considered, and the required thicknesses are computed.

If overlay pavements are considered, the service life of the existing pavement is calculated. A loop for each overlay strategy is established (the design option in LIFE2 is considered to have one strategy with no overlays). The service life of the strategy being considered is compared to the service life of the previous strategy. If they

are identical, the design schemes from the previous strategy are considered to be applicable and the design section in the loop is skipped. However, if the service lives are different, a unique design scheme is constructed for this strategy. PAVE then undertakes the rigid pavement design in conjunction with subroutine BTCT if base tradeoff is considered. Subroutine LYR is called to formulate the flexible design schemes. If overlaying and maintenance are to be considered, subroutine XMSTR is called. Figure D1 is graphic presentation of the flow of PAVE.

Variables

Variable	Location	Usage
A		Coverages and log of coverages to initial failure for flexible design
ACOST		Cost/sq yd for rigid pavement.
AESWL	/WES/	Array containing the tire area used to compute the equivalent single-wheel load for each vehicle.
AF		T.V., alpha factor for flexible design (see Figure D4).
AHH(10)	/HBLK/	Thickness array for rigid pavement over asphalt.
AKEF(10)	/AKBLK/	NA
AKEFT(10)	/AKBLK3/	NA
AKY	/AKBLK/	Effective subgrade modulus used for base tradeoff in SUBROUTINE BTCT.
ALARGE		T.V.
AREA	/ARBK/	Surface area of pavement (sq yd).
AXK	/LCY/	NA
A1(9)		Array containing the points defining the curve for number of tires used to compute equivalent single-wheel load in Figure D4, when the number of tires equals one.
A112(9)		Same as A1, for 12 tires.

Variable	Location	Usage
A16(9)		Same as A1, for 16 tires.
A18(9)		Same as A1, for 18 tires.
A2(9)		Same as A1, for 2 tires.
A24(9)		Same as A1, for 24 tires.
A4(9)		Same as A1, for 4 tires.
A6(9)		Same as A1, for 6 tires.
A8(9)		Same as A1, for 8 tires.
BCOST		Cost/sq yd for rigid pavement base.
BIG	/AKBLK/	Cost/sq yd for rigid pavement and base from BTCT.
BTE	/BSBLK/	NA
CBR(10)	/WES/	Array containing all the CBR values input to the program.
CCST(2,10)		T.V., CCST(1,J) is rigid pavement cost for the Jth unique design scheme. CCST(2,J) is flexible pavement cost for the Jth unique design scheme.
CDF		Cost for flexible pavement design.
CF		Cheapest cost from a strategy for maintenance and/or overlaying over an original flexible pavement.
CHKK		Absolute difference between the service lives of the present and previous strategies. If there is no difference, the design schemes from the previous strategy are retained for the present strategy.
COMPF	/BLOCKB/	Flexible complete protection method result from FROST analysis.
COMPR	/BLOCKB/	Same as COMPF, for rigid.

Variable	Location	Usage
COV(9)		Array containing the log of a standard set of coverages (0,10,25,60,100,200,1000,10000,100000) for flexible design.
COVRGD(10,20)	/MIXBLK/	Coverage level (IJ) for vehicle I at the year specified in the TM(J) array. Due to the difference in the design index-coverages relationship in roads between rigid and flexible pavement, COVRGD(1,J) is for rigid, and COVRGD(2,J) is for flexible.
CR		Same as CF, over an original rigid pavement.
CSF		Discounted maintenance and overlay cost from XMSTR for original flexible pavements.
CST		Same as CSF, for original rigid pavements.
CSTRT(10,6)	/RDSTR/	Array (I,J) containing the TIMES.OF.OVERLAYS, where J indexes the years of overlaying in strategy I.
DHD	/FMBLK/	NA
DT	/DOBK/	Value of DTHICKNESS for existing pavement, i.e., total thickness for flexible, slab thickness for rigid.
DT2Q	/DOBK/	NA
DUM(20)		T.V.
ESWL(10,20)	/WES/	Equivalent single-wheel load (I,J) in psi for vehicle I over the Jth thickness for 20 standard thicknesses.
FAC	/LCY/	NA
FACC	/IABLK/	NA
FACN	/IABLK/	NA

Variable	Location	Usage
FAIL(10,20,10)		Array containing the coverages to initial failure: FAIL(I,J,K) - where I is vehicle number J is the index of one of the 20 standard thicknesses K is the index of a CBR value.
FAIL1(10,10)		Coverages to initial failure for concrete stresses over a subgrade. FAIL1(IJ) is a stress (psi) for pavement thickness J from array HH caused by vehicle I.
FAIL2(10,10)	/EMBLK/	Same as FAIL1, for concrete stresses over asphalt.
FAIL3(10,20)		Coverages to initial failure for a particular CBR value: FAIL3(I,J) - I is the vehicle J indexes the thickness from the 20 standard thicknesses.
FCOMPF	/BLOCKB/	Flexible complete penetration method filter result from frost analysis.
FCOMPR	/BLOCKB/	Same as FCOMPF, for rigid.
FDE	/BSBLK/	Frost depth estimate read from the input FROST.DESIGN.
FLSF	/BLOCKB/	Flexible limited subgrade penetration method filter result from the frost analysis.
FLSR	/BLOCKB/	Same as FLSF, for rigid.
FRSUBF	/BLOCKB/	NA
FRSUBR	/BLOCKB/	NA
FSTRT(10)	/RLSVK/	Array containing the times of overlays for a given strategy.

Variable	Location	Usage
FTMO(10,4)	/RLSVK/	Array containing information for an overlay on a flexible original pavement: FTMO(I,1) is the type for overlay I 1 = rigid, 2 = flexible FTMO(I,2) is overlay thickness in inches FTMO(I,3) is rigid bonding 2 = partial bond, 3 = unbonded FTMO(I,4) is the subgrade modulus of reaction (effective modulus over asphalt for rigid overlays).
GIB		T.V.
HF(20)		Array containing the standard thickness set for airfields (1,2,3,4,5,10,15,20,25,30,40,50,60, 70,80,90,100,120,140,150).
HFRL(20)		Array containing the standard thickness set for roads (1,2,3,4,5,6,7,8,9,10,12,14,16,18,20, 22,24,26,28,32,36).
HH(10)	/HBLK/	Array containing thicknesses used for rigid design. Although the end points are originally defined by RANGE.OF.THICKNESS, the array is modified by PROGRAM MAIN to adjust for the actual subgrade modulus, and by PAVE to eliminate thin pavements.
I		T.V.
IA	/IABLK/	Index for wheel type for a particular vehicle: twin-tandem = 02, others = 00. When twin-tandem is indicated, the coverage level for flexible design is doubled (reference AFWL TR-70-113).
IAA(10)	/IABLK/	Array containing IA for all vehicles in the input.
IAXK	/KAYBK/	Unused index for allowing rigid pavement over asphalt; internally set to 1, YES.

Variable	Location	Usage
IBAD		Number of design factors that are too low to use in rigid design.
IBASE		NA
IBN	/AMBLK/	NA
IBTE	/BSBLK/	Index for BASE.TRADEOFF and FROST.DESIGN.
ICBR	/MXBLK/	Number of CBRs in the CBR array.
ICK		Index used for LIFE.CYCLE indicating if overlay strategies can use identical design schemes. The service lives of the original pavements for the previous and present strategies are compared. If there is no difference, the design section is skipped and the overlay strategy is applied to the previous design scheme. Otherwise, a new design scheme is formulated for the present strategy: ICK = 1, new design; ICK = 2, skip design.
ICMP		NA
ICNT	/CNT/	Number of unique design schemes.
ICOUNT	/RESTR/	Counter for overlay strategies.
ID	/DOBK/	Index for CALCULATION.TYPE: 1 = MAINTENANCE; 2 = LIFE.CYCLE; 3 = DESIGN.
IDF	/RODLOD/	NA
IDR	/RODLOD/	NA
IDRY	/SUBK/	NA

IBTE index table:

IBTE	BASE.TRADEOFF	FROST.DESIGN
1	NO	NO or READ
2	unused	
3	TRADEOFF	NO
4	TRADEOFF	READ
5	TRADEOFF	CALCULATE
6	NO	CALCULATE

Variable	Location	Usage
IFLEXNA	/BLOCKD/	NA
IFSWIT(10)	/ABLK3/	Switch for frost analysis and base tradeoff where: IBTE = 1, no effect on design IBTE = 3, IFSWIT(1) = 3, no effect on design IBTE = 4, IFSWIT(1) = 3, frost depth is read IBTE = 5, IFSWIT(1) = 3, frost depth is set for complete protection, or frost depth is calculated for partial protection IBTE = 5, IFSWIT(1) = 0, reduced strength is placed in subgrade modulus IBTE = 5, IFSWIT(1) = 2, partial protection uses input subgrade modulus and calculated frost depth IBTE = 6, IFSWIT(1) = 0, reduced strength causes redesign of pavement with a reduced subgrade modulus.
IGINT	/MXBLK/	NA
II		T.V.
IIBAD		T.V.
IIL		T.V.
IIX(10,10)	/FMBLK/	Identifies the layers used in a unique flexible design scheme: IIX(1,J) is the number of layers in design scheme J, plus one IIX(I,J) is the number of the (I-1) layer for scheme J.
IMAN	/RDSTR/	Unused index for internal strategy generation. Internally set to 2, NO.
IMIX	/MIXBLK/	Number of VEHICLE.TYPE input
IREST	/RESTR/	Index for DESIGN.RESTRICTION: 1 = NONE 2 = RIGID 3 = FLEXIBLE.

Variable	Location	Usage
IRIGIDNA	/BLOCKD/	Frost protection method for rigid 1 = complete protection 2 = partial protection 6 = partial protection and reduced subgrade strength.
IRL	/BLBLK/	NA
ITY	/DOBK/	Index for DTYPE: 1 = RIGID 2 = FLEXIBLE.
IUBC	/SUBK/	NA
IX(20)		Contains the flexible layer numbers for each design scheme.
J		T.V.
JDL	/SCAN3/	DESIGN.LIFE of pavement in years.
JJ		T.V.
JMAN	/MANLK/	NA
JREST	/RESTR/	NA
JXX(20,20)	/MANLK/	NA
K		T.V.
KBAD		T.V.
KCOST		Number of flexible design schemes in a strategy.
KK		T.V.
KKKL		T.V.
LFUNC	/TYPBK/	NA
LIMT	/XMBLK/	Indicates whether only one type of pavement (rigid or flexible) or both types are possible beneath the overlay.

Variable	Location	Usage
LLYR		T.V.
LMH	/TYPBK/	NA
LS	/LCY/	Number of years specified by the TIMES input at which thickness calculations are to be made.
LZ	/RODLOD/	Indicates road design when equal to 3.
M		T.V.
MF		T.V.
MCYST	/MANLK/	Number of subbase schemes.
MNT	/DOM/	Number of the dominant vehicle (dominance is defined as the greatest concrete stress at the lowest pavement thickness).
MNTO	/SZBK/	NA
MQ		T.V.
MTX		T.V.
MXN	/AMBLK/	NA
MXTO	/SZBK/	NA
NB	/LYTD/	Number of flexible base layers.
NCOM	/LYTD/	Number of compacted subgrade layers within one flexible design scheme.
NFLEX	/TYP/	Set to zero if DESIGN.RESTRICTION and OVERLAY.RESTRICTION are both RIGID, i.e., no flexible designs or overlays are allowed.
NFSTRT	/RLSVK/	Number of overlays on a flexible pavement in one strategy.
NKOM		NA

Variable	Location	Usage
NLYR		NLYR equals the number of subbase layers within a scheme plus the number of compacted subgrade layers within a scheme minus one. If there are no compacted subgrade layers, NYLR equals the number of subbase layers within a scheme.
NLYST	/NANLK/	Number of different compacted subgrade combinations.
NNAT	/LYTD/	NA
NODQ	/NBLK/	NA
NOGQ	/NBLR/	NA
NOH	/NBLK/	Number of thicknesses in the HH array, less than or equal to 10.
NOI		T.V.
NOO(10)	/RDSTR/	Array containing the number of overlays within each strategy.
NOOQ		Number of overlays within a given strategy.
NOSGQ	/NBLK/	NA
NPASS	/PASSBK/	Indicates when at least one strategy has been completed. NPASS is used in subroutines GXMT and GZCBR to signal that the layer CBR values have already been sorted.
NPTQ	/NBLK/	NA
NQLYR		NA
NRIGID	/TYP/	Index for RIGID.STRUCTURAL.ANALYSIS: 0 = none 1 = CALCULATE 2 = READ.

Variable	Location	Usage
NRSTRT	/RLSVK/	Number of overlays on a rigid pavement in one strategy.
NSBB	/LYTD/	NA
NSSTRT		Same as NRSTRT (obsolete).
NTSTRT		Same as NFSTRT (obsolete).
NUMS	/RDSTR/	Number of overlay strategies.
NX		Number of overlay strategies being considered.
NXQ	/NBLK/	NA
NXX		T.V.
NY00(20)	/MANLK/	NA
NYQ	/NBLK/	NA
PAVT	/AKBLK/	Rigid pavement thickness.
PRDBTF	/BLOCKB/	NA
PRDBTR	/BLOCKB/	NA
PRFLTF	/BLOCKB/	NA
PRFLTR	/BLOCKB/	NA
PVTFLX	/BLOCKD/	NA
PVTRGD	/BLOCKD/	Rigid pavement thickness used in frost analysis.
RSTRT(10)	/RLSVK/	Number of overlays on a rigid pavement within one strategy.
RSUBF	/BLOCKB/	NA
RSUBR	/BLOCKB/	NA
RTMO(10,4)	/RLSVK/	Same as FTMO, for rigid original pavement.

Variable	Location	Usage
SLSDBTF	/BLOCKB/	Result from frost analysis for limited subgrade penetration method, for flexible pavement.
SLSDBTR	/BLOCKB/	Same as SLSDBTF, for rigid pavement.
SLSPENF	/BLOCKB/	NA
SLSPENR	/BLOCKB/	NA
SSTRT		Same as RSTRT (obsolete).
STMO(10,4)		Same as RTMO (obsolete).
STORE(20)		Temporary storage for array THFF for the subgrade.
STORE1(10,10)	/MIXBLK/	Array containing the concrete stresses on grade (psi): STORE1(I,J) where I is the vehicle number J indexes the thicknesses from the HH array.
STORE2(10,10)	/MIXBLK/	Same as STORE1, except for concrete stresses over asphalt.
SUBD	/SUBK/	NA
SVCOST		Cost of rigid pavement and base.
TA		Result from subroutine PECHART; represents thickness divided by the square root of the tire area.
TAKY		T.V.
TBIG		T.V.
TBS	/AKBLK/	Base thickness for rigid pavement.
THF(20)		Same as THFF, except actual unrounded values.
THFF(20)	/THKBK/	Array of required thicknesses for each CBR at each of the years specified for thickness calculations by the TM array. THFF(I) contains the thicknesses for the subgrade after each CBR value is stored in XFP array.

Variable	Location	Usage
		Thicknesses are rounded at 1/4 in. (6.35 mm).
THK(10,10)	/FMBLK/	Array containing layer thicknesses THK(1,J) is the rigid pavement thickness for the design scheme J. THK(I,J) is the (I-1) layer thickness for scheme J.
TM(20)	/HBLK/	Array containing the years specified for thickness calculations, as input by the user via the TIMES variable or as calculated in the program by default values.
TMT(20)		Array from subroutine LYR containing the flexible layer thicknesses for a flexible design scheme.
TPAVT		T.V.
TRA(20)	/BMBLK/	NA
TRAA(20)	/BMBLK/	NA
TRK(20)		Same as TRKK, unrounded.
TRKK(20)	/THKBK/	Rigid pavement thickness required above the subgrade at each of the years specified by the TM array, rounded at 1/4 in. (6.35 mm). These thicknesses can be decreased by base tradeoff.
TRPQZ(20)	/PQZ/	Saves the original TRKK calculated over the subgrade modulus.
TRST	/DMBLK/	NA
TRY(20)	/LCY/	NA
TSTRT(10)		Same as FSTRT (obsolete).
TT		Rigid pavement slab thickness.
TTBS		T.V.
TTMO(10,4)		Same as FTMO (obsolete).

Variable	Location	Usage
TTRKK(20)		T.V.
TTT		Rigid pavement plus base thickness.
T1	/T1BK/	Rigid pavement base thickness.
W		T.V.
WHEELS(10)	/WES/	Array containing number of tires used to compute ESWL for each vehicle.
WHHELS		Number of tires used to compute ESWL for a particular vehicle.
X		T.V.
XAB		T.V.
XCBR	/LCY/	Value of SUBGRADE.CBR.
XFP(20,10)	/SG5WP2/	Array containing the required thicknesses of pavement for different CBRs at different times; XFP(I,J) is THFF(I) for CBR(J).
XK	/NBLK/	SUBGRADE.MODULUS in pci.
XMT(10,6)	/LYTD/	NA
XSTR	/LCY/	CONCRETE.FLEXURAL.STRENGTH in psi.
XTRA	/BLOCKB/	NA
XXA		Coverages to failure for concrete stresses over asphalt from the inline functions RCOVLO and RCOVHI. RCOVLO is the first segment, and RCOVHI is the second segment from the design factor-coverages to failure curve (Figure D2) for K = 25 to 200.
XXK		Same as XXA, for concrete stresses on grade.
XXO		Contains service life XXT from previous overlay strategy.
XXT		Pavement service life.

Variable	Location	Usage
X1		Design factor for concrete stresses on grade.
X2		Design factor for concrete stresses over asphalt.
Y		T.V.
YCBR(10,4)	/LYTD/	NA
YK	/LCY/	NA
Y1		T.V.
Y2		T.V.
Y3		T.V.
ZCBR(10,6)	/LYTD/	NA
ZMT(3,4)	/LYTD/	NA
Z1		T.V.
Z2		T.V.
Z3		T.V.

Common Blocks

The common blocks in PAVE are

ABLK3, AKBLK, AMBLK, ARBK, BLBLK, BLOCKB, BLOCKD, BMBCK, BSBLK, CNT, DMBLK, DOBK, DOM, EMBLK, FMBLK, HBLK, IABLK, KAYBK, KCY, LTTBLK, LYTD, MANLK, MIXBLK, MXBLK, NANLK, NBLK, PASSBK, PQZ, RDSTR, RESTR, RLSVK, RODLOD, SCAN3, SG5WP2, SUBK, SZBK, THKBK, TYP, TYPBK, T1BK, WES, XMBLK.

Tapes

The tapes used by PAVE are:

TAPE5 -- stores and transfers design information
TAPE6 -- writes general information to the debug file
TAPE7 -- stores and transfers design information
TAPE8 -- writes messages to the user.

Traceback

PAVE is called by MAIN as the driver for OVERLAY (3,0) and calls BTCT, GINT, LYR, MIXED, PECHART, RODTHK, SERCST, XMSTR, the system routines ABS, AINT, ALOGIO, FLOAT, and SQRT, and the inline functions RCOVLO and RCOVHI (see variables XXA and XXK).

Illustrations

Figure D1 is a descriptive flowchart of PROGRAM PAVE. Figure D2 is the design factor-coverages to failure curve. Figure D3 shows the relationship between CBR, gear load, tire area, and flexible pavement thickness. Figure D4 relates load repetitions, number of tires, and coverages.

References

G. M. Hammitt II, et al., *Multiple Wheel Heavy Gear Load Pavement Tests*, Vol IV, Technical Report No. 70-113, Vol IV, (Air Force Weapons Laboratory, Kirtland Air Force Base, November 1971). Also see Technical Report No. 71-17 (Waterways Experiment Station, November 1971).

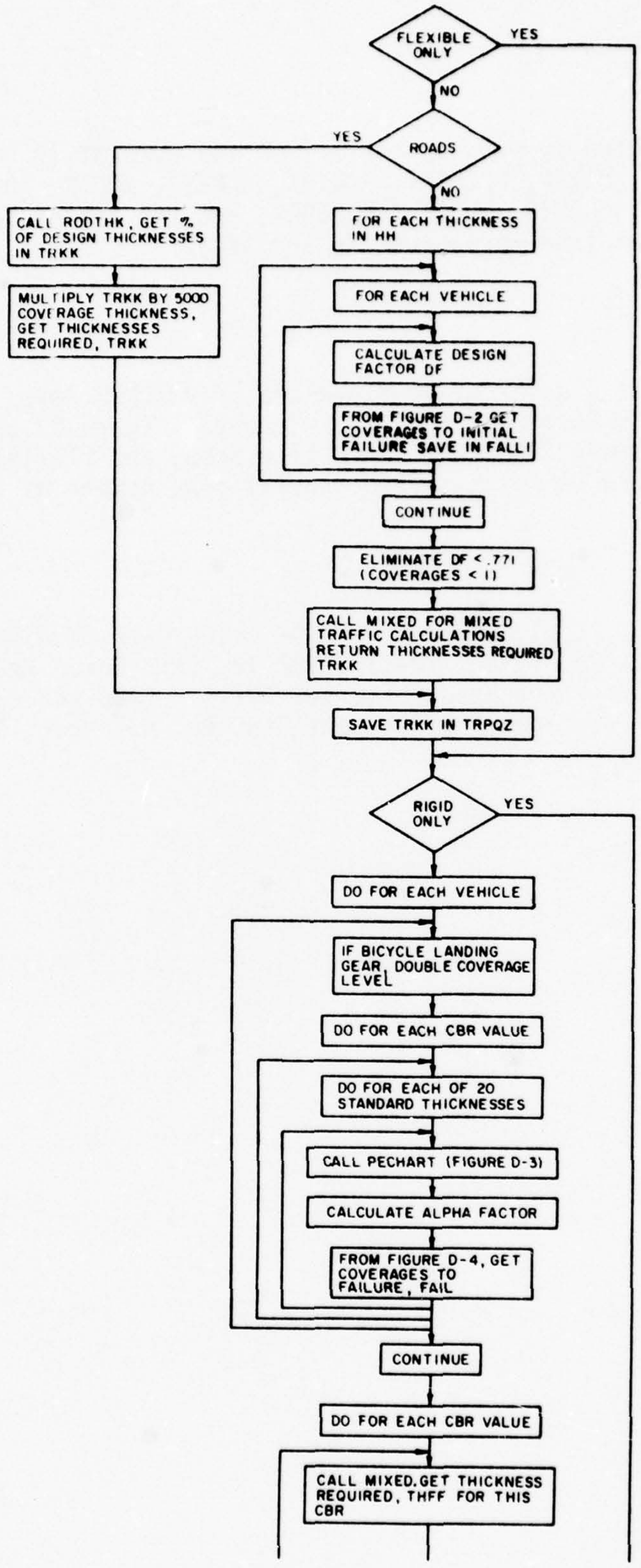


Figure D1. Descriptive flowchart of PAVE.

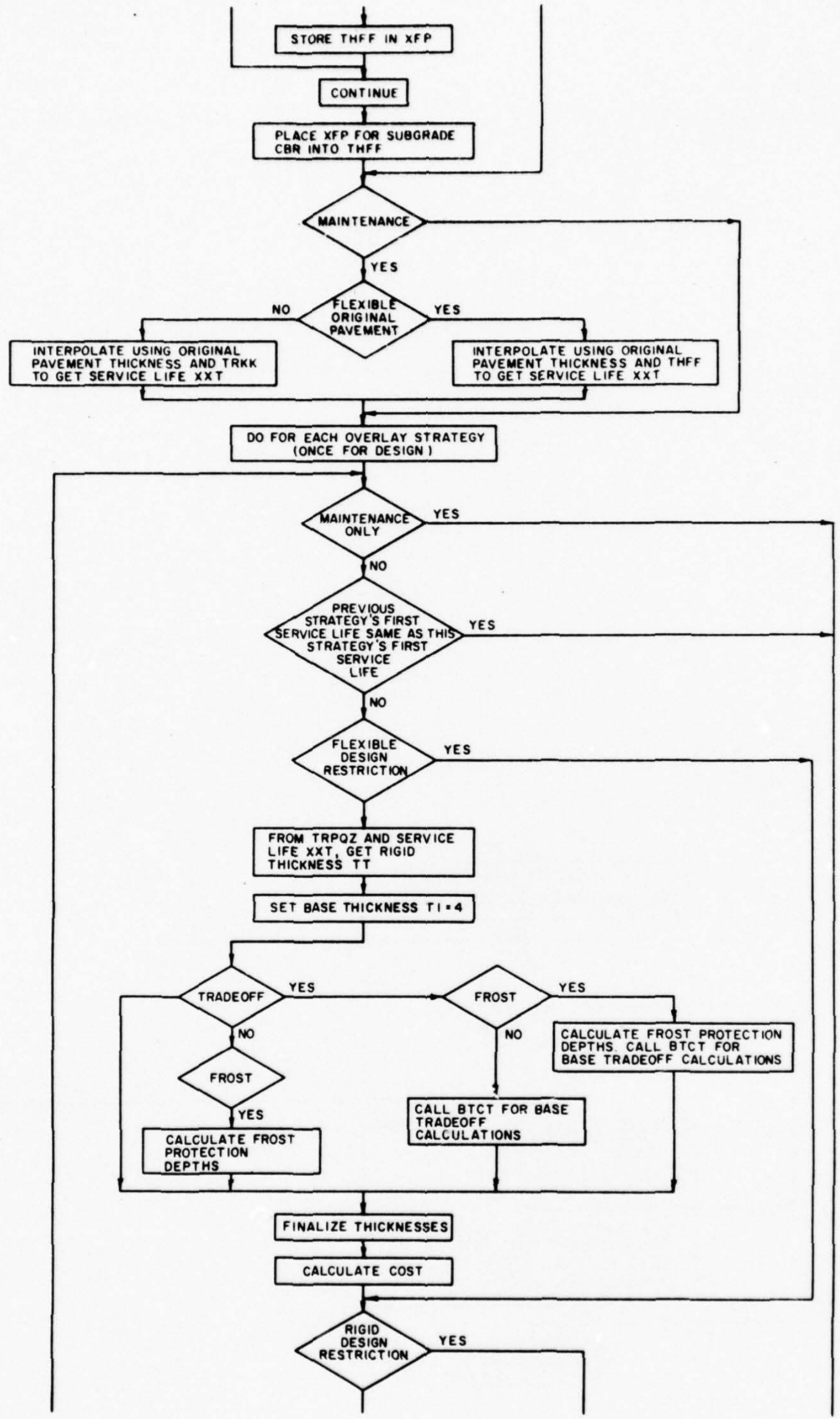


Figure D1 (cont'd).

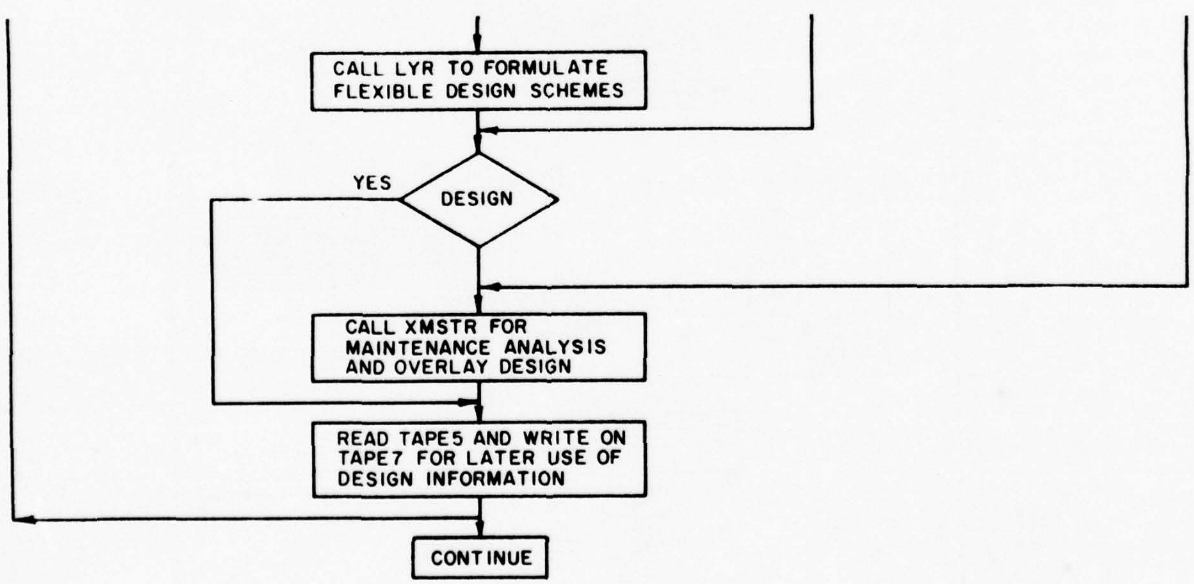


Figure D1 (cont'd).

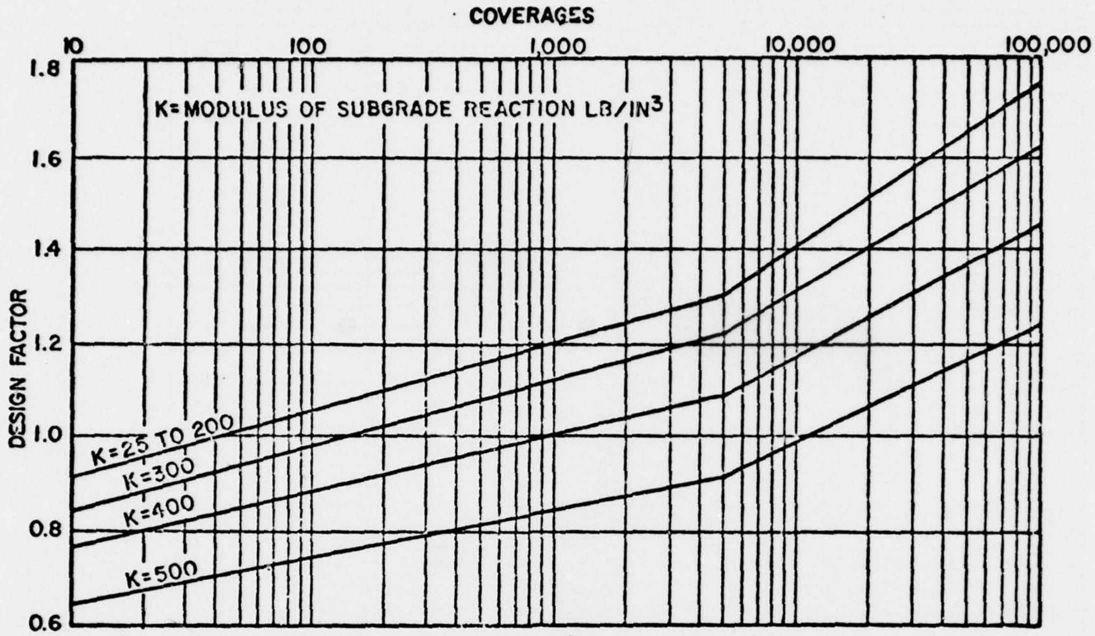


Figure D2. Design factor vs. coverage for initial failure conditon. Pass per coverage ratios for 12-wheel and twin-tandem assemblies = 1.34 and 3.30, respectively. (From Figure 12, AFWC TR 70-113).

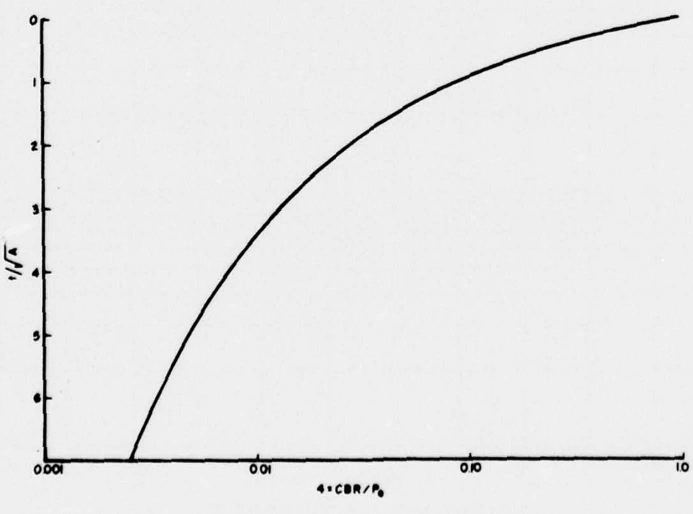


Figure D3. Complete $t/\sqrt{A}$ vs. CBR/P_e. (From Figure 38, AFWC TR 70-113).

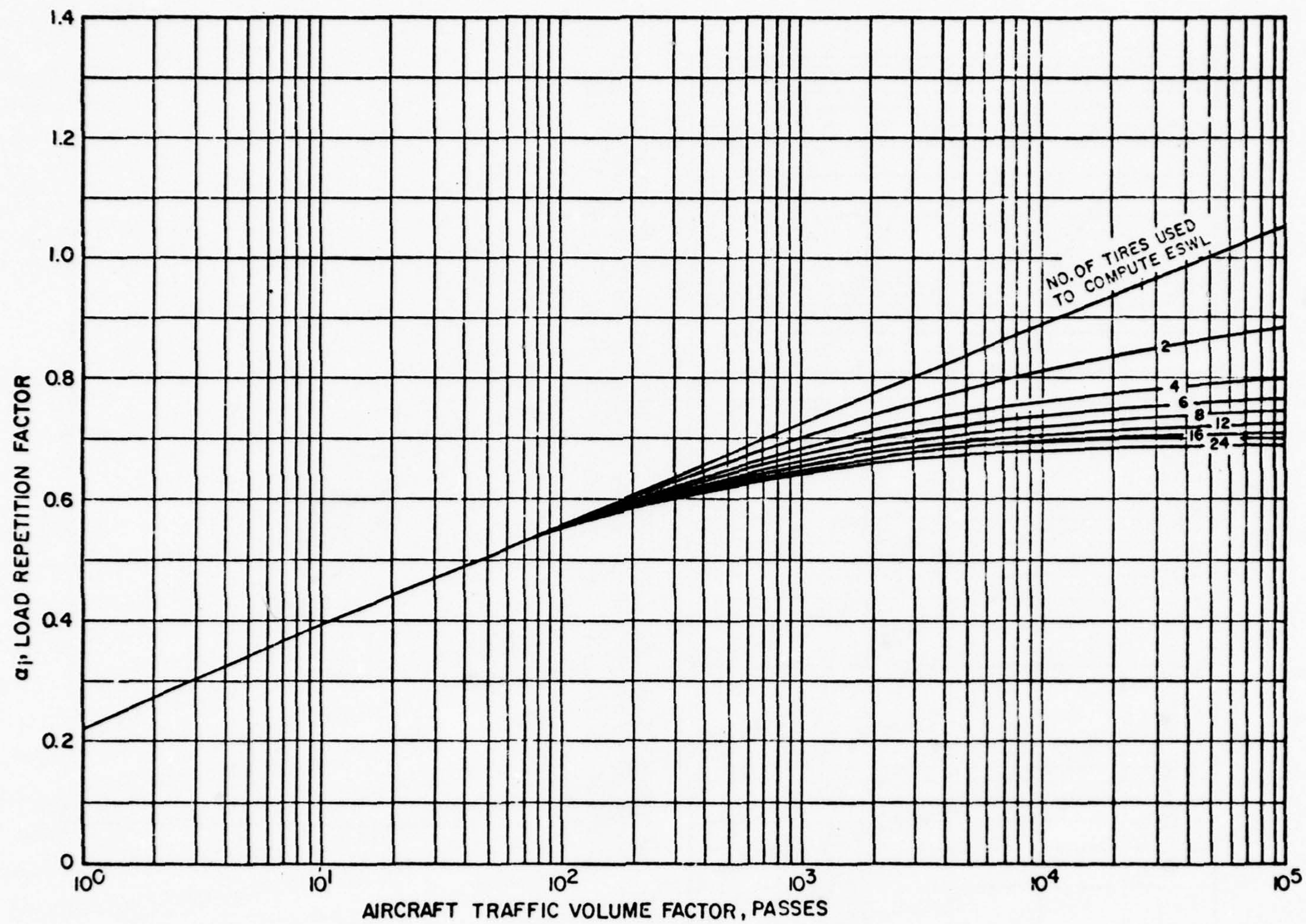


Figure D4. Composite plot of load repetition factors vs. passes. (From Figure 37, AFWC TR 70-113).

LYR

Purpose

This subroutine combines the input flexible pavement materials into design schemes and determines their required thicknesses.

Formal Parameters

The header card for LYR is:

SUBROUTINE LYR(XXT,TMT,CDF,IX,NLYR).

Description

LYR employs user-supplied, or program-generated, material combinations to determine layer thicknesses based on density requirements. The thicknesses may be adjusted due to climatic considerations or minimum material thicknesses. Figure D5 describes the flow of this subroutine.

Variables

Variable	Location	Usage
AESWL(10)	/WES/	NA
AREA	/ARBK/	Area (sq yd).
AXKQ	/LCY/	NA
BASET		Result from subroutine MTHICK for minimum thickness of base in road design.
CBR(10)	/WES/	Array containing all the CBR values in the input. Stored in increasing order.
CBRL		CBR of base for road design.
CDF	FP	Cost of the cheapest flexible construction scheme.
CDF1		Cost/sq yd for a pavement layer.
CDF2		Cost/sq yd for a pavement layer.
DENS		Percent of maximum dry density.

Variable	Location	Usage
DIFF		Increase in thickness in one material due to minimum thickness requirements. Used to decrease other materials if possible.
DN		T.V. used to find density index.
DPTH(20)		Array containing depth to top of each material.
DT	/DOBK/	NA
DT2Q	/DOBK/	NA
ESWL(10,20)	/WES/	NA
FACQ	/LCY/	NA
FDE	/BSBLK/	Estimate of required depth of frost protection (inches) for FROST.DESIGN.
FDEF	/BSBLK2/	Calculated required depth of frost protection (inches) for FROST.DESIGN.
HHQ(10)	/HBLK/	NA
I		T.V.
IBAS		T.V. for number of base layers.
IBASE		Index indicating CBR of base layers. 1 = CBR >90 2 = 70 < CBR ≤90 3 = 50 ≤ CBR ≤70.
IBTE	/BSBLK/	Index for BASE.TRADEOFF and FROST. DESIGN:
ICBR	/MXBLK/	Number of CBR values.

IBTE	BASE.TRADEOFF	FROST.DESIGN
1	NO	NO or READ
2	unused	
3	TRADEOFF	NO
4	TRADEOFF	READ
5	TRADEOFF	CALCULATE
6	NO	CALCULATE.

Variable	Location	Usage
ICMP		Number of first compacted subgrade material.
ID	/DOBK/	NA
IDENS		Upper index for percent maximum density.
IDENT		Lower index for percent maximum density:

CBR	IDENS	IDENT
100	1	1
99-95	2	1
94-90	3	2
89-85	4	3
84-80	5	4
79	5	5

Variable	Location	Usage
IDF	/RODLOD/	Flexible pavement design index (1-10).
IDR	/RODLOD/	NA
IDRY	/SUBK/	Index indicating climate: 1 = normal 2 = dry.
IGINT	/MXBLK/	NA
II		Index for loading the YMT and the IY arrays.
IIL		T.V.
IOH		Index for cohesion and frost susceptibility (FS): 1 = COHESIONLESS, NFS 2 = COHESIVE, NFS 3 = COHESIONLESS, FS 4 = COHESIVE, FS.
IPBQ		Index designating whether material is pavement or base 1 = pavement 2 = base.

Variable	Location	Usage
IQCMP		T.V. used as a counter for the number of compacted layer combinations.
ISB		Index designating CBR of layer beneath base: 1 = CBR < 80 2 = CBR $\geq$ 80.
ITY	/DOBK/	NA
IUBC	/SUBK/	SUBGRADE.COHESION.INDEX (same code as IOH).
IX(20)	FP	Array containing the material numbers for the layers in a scheme.
IXBS		Base material number.
IXCMP		Same as ICMP.
IXSB		Same as ISB.
IXT(20)		Temporary array for IX(20).
IXXC		Material number indicating first frost susceptible layer from the top.
IY(20)		Array containing the cohesion and frost susceptibility codes for the materials in a scheme (from subgrade to base course): 1 = COHESIONLESS, NFS 2 = COHESIVE, NFS 3 = COHESIONLESS, FS 4 = COHESIVE, FS.
IYSC		NA
J		T.V.
JJ		Material number from IX array.
JJKM		T.V.
JJMN	/GLINK/	Number of subbase combinations.

Variable	Location	Usage
JMAN	/MANLK/	Index for GENERATE.MATERIAL.COMBINATIONS: 1 = YES 2 = NO.
JXMT		When equal to 1, indicates that the material above the natural subgrade is a subbase with a CBR20. This skips the density requirement.
JXX(20,20)	/MANLK/	Array containing SUBBASE.TYPES: JXX(IJ) where I is a scheme number and J corresponds to subbases in scheme I.
K		T.V.
KK		Counter for layers.
KL		T.V.
KLASS		Index for CLASS.OF.ROAD: 1 = A 3 = C 5 = E 2 = B 4 = D 6 = F
KX(20)	/KEYVAL/	Array containing the subbase material numbers for one possible combination; from subroutine GXMT.
L		Layer counter.
LFUNC	/TYPBK/	Index for TRAFFIC.AREA or CLASS.OF.ROAD (same code as KLASS).
LL		Sum of the number of materials comprising the base, subbase, compacted subgrade, and natural subgrade layers in the design scheme.
LLYR		Sum of the number of materials comprising the pavement, base, subbase, and compacted subgrade layers in the design scheme.
LL1		LL + 1, to include subgrade.

Variable	Location	Usage
LMH	/TYPBK/	Load category: 1 = light load 2 = medium load 3 = heavy load.
LPASS	/PASSCK/	Pass switch for subroutine GZCBR.
LS	/LCY/	Number of years specified by the TIMES input at which thickness calculations are to be made.
LX		Same as LS.
LY		Same as ICBR.
LZ	/RODLOD/	Indicates road design when equal to 3.
M		T.V.
MA		T.V.
ML		T.V.
MLYST	/MANLK/	Number of subbase combinations.
MM		T.V.
MNTO	/SZBK/	NA
MPASS		Indicates pass number.
MX(20)	/CEYVAL/	Array containing the compacted subgrade material numbers for one possible combination; from subroutine GZCBR.
MXTO	/SZBK/	NA
NB	/LYTD/	Number of base layers.
NCALL		Index for locating cost information.
NCLYR		Number of compacted subgrades in a scheme.

Variable	Location	Usage
NCOM	/LYTD/	Value of total number of completed subgrades is saved in NKOM; indicates existence (1) or nonexistence (0) if compacted subgrade materials are input.
NCST(20)		Array containing the cost indices for the materials in a pavement scheme.
NKLYR		Equals NCLYR-1.
NKOM		Number of compacted subgrades in input.
NL		T.V.
NLYR	FP	NYLR equals the number of subbase layers within a scheme plus the number of compacted subgrade layers within a scheme minus one. If there are no compacted subgrade layers, NLYR equals the number of subbase layers within a scheme.
NLYST	/NANLK/	Number of compacted subgrade combinations.
NNAT	/LYTD/	Number of natural subgrade layers.
NQBB		Number of subbases in input.
NQLYR		Number of subbase materials within a scheme.
NSBB	/LYTD/	Total number of subbases and compacted subgrades in the input minus one.
NX(20)		T.V.
NXLY		Number of subbases and compacted subgrades in a scheme minus one.
NYOO(20)	/MANLK/	Number of subbases in scheme I.
SUBD	/SUBK/	Percent maximum density of subgrade.
TAX		Depth, from array DPTH, to the bottom of the layer being considered.
TDRY		Factor used for pavement thickness reduction due to a dry climate.

Variable	Location	Usage
TFOB		Additional thickness required above the natural subgrades due to the strength requirements of one of the natural subgrades.
THFF(20)	/THKBK/	Array of required thicknesses for each CBR layer at each of the years specified for thickness calculations by the TM array.
THH		Thickness of a natural subgrade.
THIKENS		Minimum pavement thickness for road design.
TLIM		Thickness result from subroutines TLMC, RODDENS, and TLMM.
TLMB		Base thickness.
TM(20)	/MBLK/	Array containing the years specified for thickness calculations, as input by the user via the TIMES variable or as calculated in the program by default values.
TMLB		Required thickness.
TMT(20)	FP	Array containing the flexible layer thicknesses for a flexible design scheme.
TRYQ(20)	/LCY/	NA
TTT		Material thickness for cost calculations.
TX		Required thickness above a material, originally due to density requirements.
TXX		Required thickness above a material, originally due to subgrade CBR and service life requirements.
TYY		Thickness (inches) required above the subgrade due to compaction requirements.
TZZ		Thickness (inches) required at service life XXT based on CBR strength.
WHEELS(10)	/WES/	NA
XCBR	/LCY/	Value of SUBGRADE.CBR.

Variable	Location	Usage
XCD		Cost of cheapest scheme.
XFP(20,10)	/SG5WP2/	NA
XMT(10,6)	/LYTD/	Array containing characteristics of up to 10 possible subbase layers, where: XMT(I1) is the CBR of layer I, XMT(I,2) is the density, XMT(I,3) is unused, and XMT(I,4) is the IUBC (cohesion, frost susceptibility) code.
XRR		CBR of the material above the material being considered.
XTMT(20)		Temporary array for TMT(20).
XXR		CBR value of the material being considered.
XXT	FP	Service life of original pavement design.
YCBR(10,4)	/LYTD/	Array containing characteristics of up to 10 possible natural subgrade layers, where YCBR(I,1) is the CBR of layer I, YCBR(I,2) is the density, YCBR(I,3) is the layer thickness, and YCBR(I,4) is the IUBC code.
YKQ	/LCY/	NA
YMT(20)		Array containing the CBR values of the materials in a scheme, from the natural subgrades to the base.
ZCBR(10,6)	/LYTD/	Array containing characteristics of up to 10 possible compacted subgrade layers, where ZCBR(I,1) is the CBR of layer I, ZCBR(I,2) is the density, ZCBR(I,3) is unused, and ZCBR(I,4) is the IUBC code.
ZMT(3,4)	/LYTD/	Array containing the CBR values for up to three base materials, where ZMT (I,1) is the CBR of layer I.

Common Blocks

Common blocks in LYR are:

ARBK, BSBLK, BSBLK2, CEYVAL, DOBK, GLINK, HBLK, KEYVAL, LCY, LYTD, MANLK, MXBLK, NANLK, PASSCK, RODLOD, SG5WP2, WUBK, SZBK, THKBK, TYPBK, WES.

Tapes

Tapes used in LYR are:

TAPE5 -- saves the flexible design schemes

TAPE6 - writes information to the debug file.

Traceback

Subroutine LYR is called by PAVE and calls the following subroutines: GINT, GXMT, GZCBR, HINT, MTHICK, RODDENS, SERCST, TLMC, TLMM, and the inline functions AINT, FLOAT, INT.

Illustrations

Figure D5 is a descriptive flowchart of LYR.

References

Airfields Flexible Pavement, Technical Manual 5-824-2 (Department of the Army, February 1969).

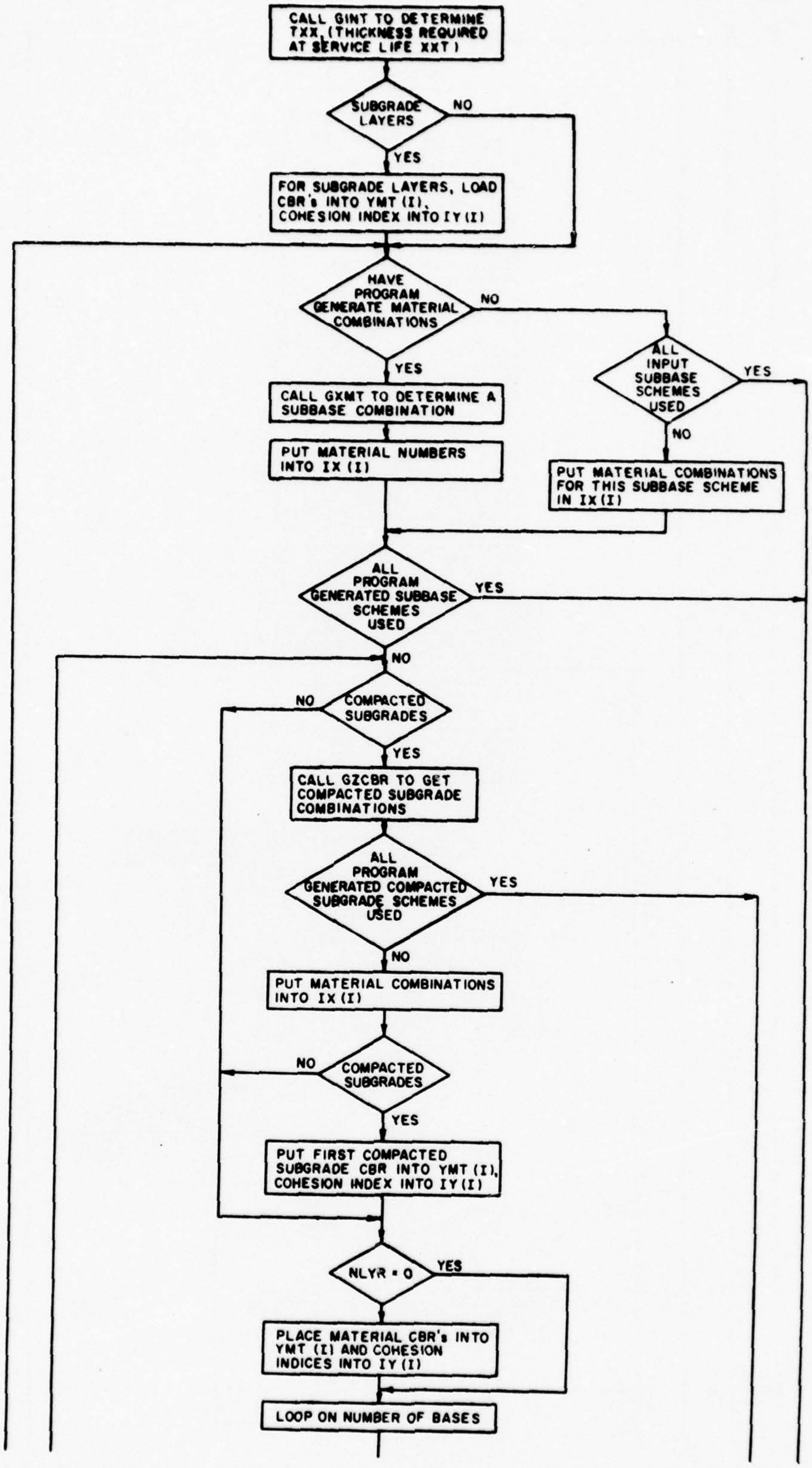


Figure D5. Descriptive flowchart of LYR.

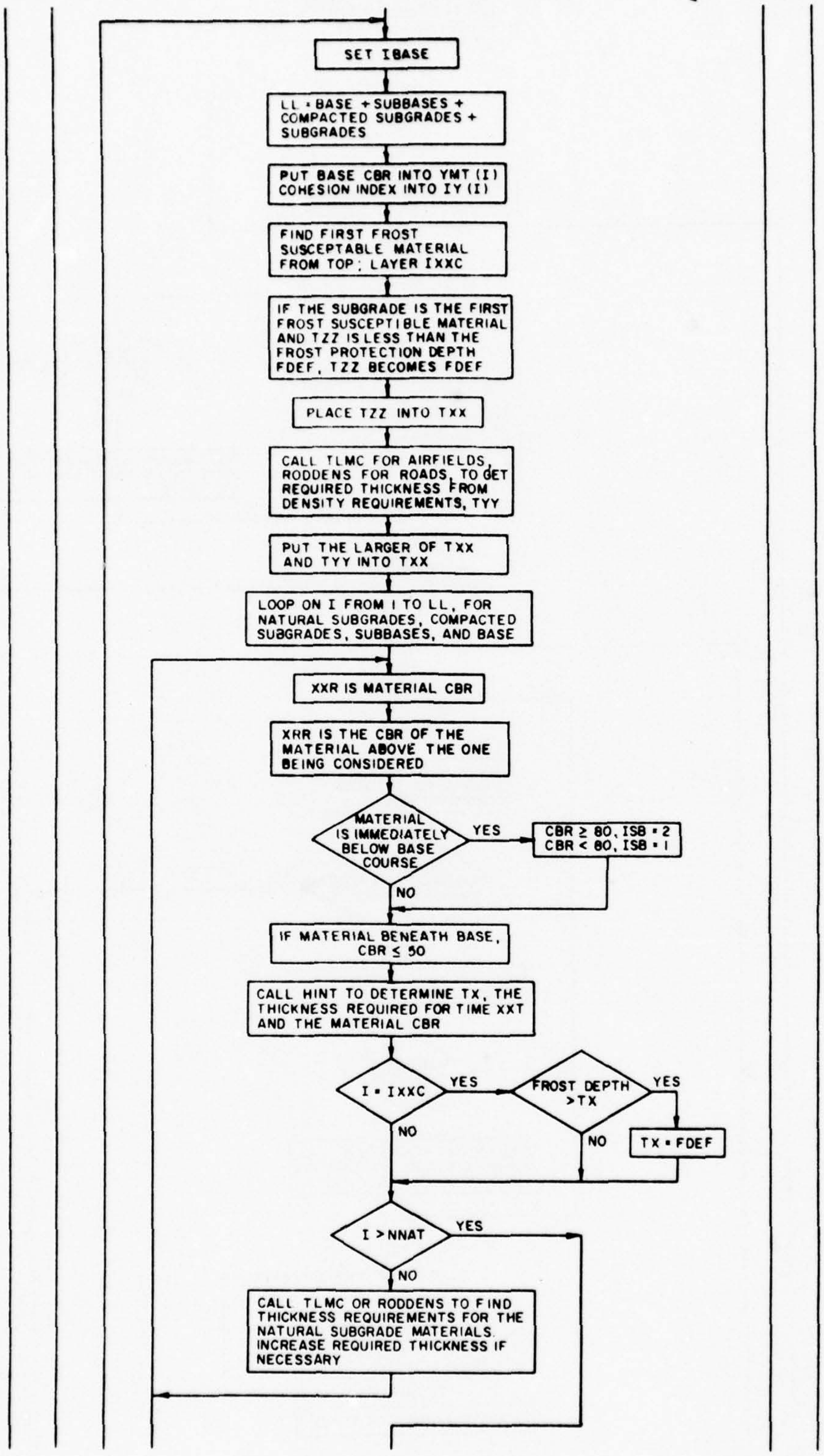


Figure D5 (cont'd).

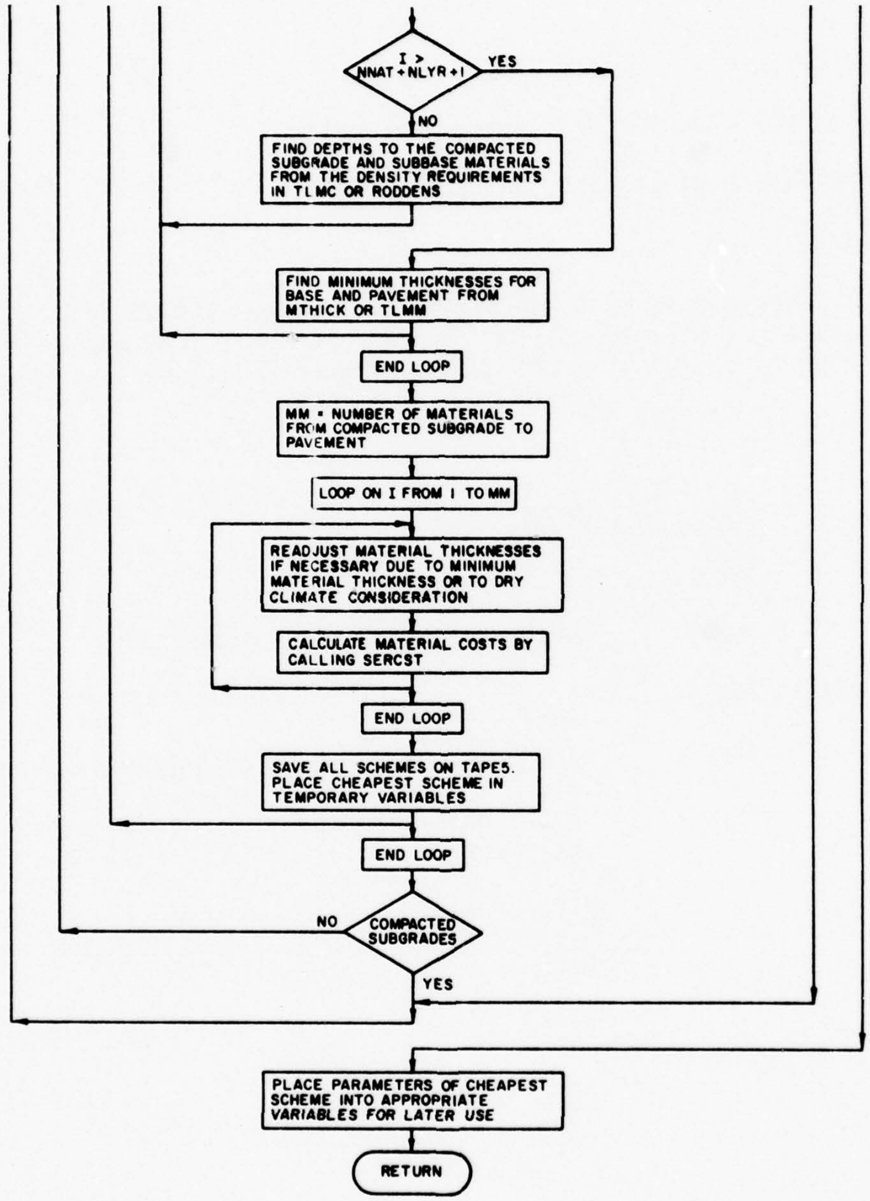


Figure D5 (cont'd).

HINT

Purpose

Subroutine HINT is used for interpolation in a two-dimensional array.

Formal Parameters

The header card for HINT appears as follows:

SUBROUTINE HINT (TX,XXV,XXR,LX,LY,XCV).

Description

HINT interpolates in a two-dimensional array--XFP(20,10). XFP contains thicknesses related to TIME and CBR. Given a TIME and a CBR, HINT interpolates to arrive at a thickness. Figure D6 illustrates the procedure.

Variables

Variable	Location	Usage
AESWL(10)	/WES/	NA
CBR(10)	/WES/	Array containing CBR values.
ESWL(10,20)	/WES/	NA
LX	FP	Number of years for which thicknesses are given.
LY	FP	Number of CBR values for which thicknesses are given.
SLX		T.V.
SLX1		T.V.
SLX2		T.V.
SLY		T.V.
SLY1		T.V.
SLY2		T.V.

Variable	Location	Usage
SSLX		T.V.
SSLY		T.V.
TX	FP	Thickness required at service life XXV and at layer CBR XXR.
WHEELS(10)	/WES/	NA
XCV(20)	FP	Array containing years at which calculations are to be made.
XFP(20,10)		Array of thicknesses required for each CBR value at each of the years specified in XCV array.
XXR	FP	Input CBR value at which thickness is required.
XXV	FP	Input time at which thickness is required.
ZX		T.V.
ZY		T.V.
Z1		T.V.
Z2		T.V.

Common Blocks

The common blocks in HINT are SG5WP2 and WES.

Tapes

None.

Traceback

Subroutine HINT is called by LYR and calls no other subroutines.

Illustrations

Figure D6 shows the procedure used in HINT.

References

None.

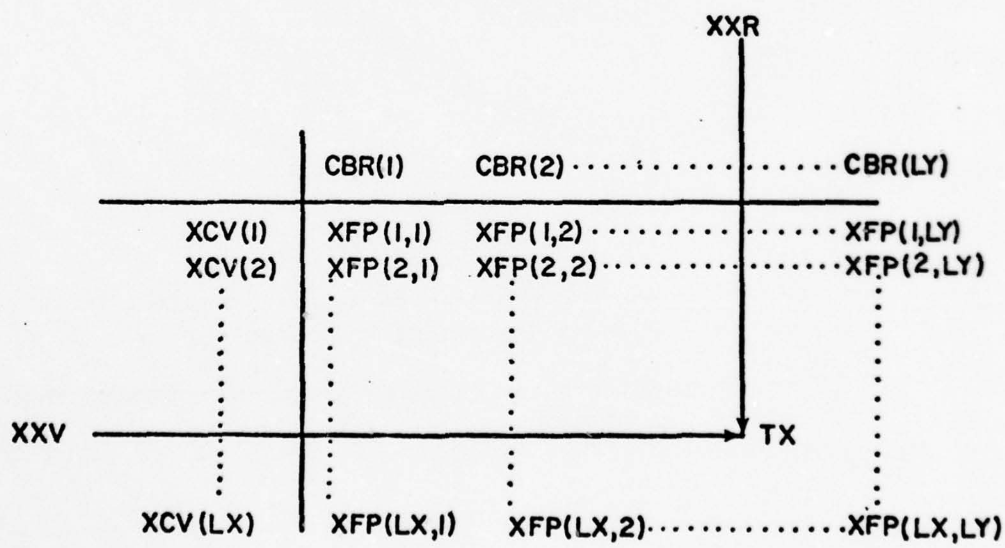


Figure D6. Procedure used in HINT.

GXMT

Purpose

GXMT is designed to determine all possible material combinations for the subbase layer.

Formal Parameters

The header card for GXMT appears as follows:

SUBROUTINE GXMT(NSBB,NLYR).

Description

Array XMT contains the CBRs for all of the subbase materials. These materials are ordered in GXMT by increasing CBR value the first time this subroutine is called. During successive calls, GXMT provides all possible combinations of these materials. Each call places a combination of materials in array IX, counts the materials in that combination as NLR, and returns this information to LYR. Note that the only combinations allowed are those with successively increasing material CBRs. When all combinations are exhausted, NLYR is set to zero as a flag. For example, if four subbase materials are input (with increasing CBRs from subbase 1 to 4), GXMT would successively return the following combinations in array IX:

1;2;3;4;1-2;1-3;1-4;2-3;2-4;3-4;1-2-3;1-2-4;1-3-4;2-3-4; and 1-2-3-4.

Variables

Variable	Location	Usage
I		T.V.
IMAX(20)		T.V.
IPOINT(20)		T.V.
IROW(20)		Contains the subbase material numbers in order of increasing CBR values.
ISWIT		Indicates a CBR value has been reordered when equal to one.
ITMP		T.V.

Variable	Location	Usage
IX(20)	/KEYVAL/	Array containing the subbase material numbers for one possible combination. The number of materials in this array for each return is given by NLYR.
J		T.V.
KK		T.V.
LPTR		T.V.
N		T.V.
NCOM	/LYTD/	NA
NLYR	FP	Number of subbase materials in array IX, equal to zero when all possibilities are exhausted.
NNAT	/LYTD/	NA
NPASS	/PASSBK/	Switch: 1 = first pass through GXMT, perform CBR sort 2 = CBRs have been sorted, initialize variables 3 = successive call, no initialization.
NSBB	FP	Total number of subbase materials.
NSQQ	/LYTD/	NA
NSWTH		Variable for GO TO statement.
ORG		T.V.
OTEMP		T.V.
TEMP		T.V.
XMT(10,6)	/LYTD/	Array containing subbase material information. XMT(I,1) is the CBR for the Ith subbase.

Variable	Location	Usage
XMTK(20)		Internal array for XMT(I,1). May be reordered according to increasing CRB value.
YCBR(10,4)	/LYTD/	NA
ZCBR	/LYTD/	NA

Common Blocks

The common blocks in GXMT are LYTD, KEYVAL, and PASSBK.

Tapes

None.

Traceback

GXMT is called by LYR and calls no routines.

Illustrations

None.

References

None.

GZCBR

Purpose

GZCBR is designed to determine all possible material combinations for the compacted subgrade layer.

Formal Parameters

The header card for GZCBR appears as follows:

SUBROUTINE GZCBR(NSBB,NLYR).

Description

Array ZCBR contains the CBRs for all of the compacted subgrade materials. These materials are ordered by increasing CBR value the first time GZCBR is called. During successive calls, GZCBR provides all possible combinations of these materials. Each call places a combination of materials in array IX, counts the materials in that combination as NLYR, and returns this information to LYR. Note that the only combinations allowed are those with successively increasing material CBRs. When all combinations are exhausted, NLYR is set to zero as a flag. The procedure is similar to that used in GXMT for subbase materials.

Variables

Variable	Location	Usage
I		T.V.
IMAX(20)		T.V.
IPOINT(20)		T.V.
IROW(20)		Contains the compacted subgrade material numbers in order of increasing CBR values.
ISWIT		Indicates a CBR value has been reordered when equal to one.
ITMP		T.V.
IX(20)	/CEYVAL/	Array containing the compacted subgrade material numbers for one possible combination. The number of materials in this array for each return is given by NLYR.

Variable	Location	Usage
J		T.V.
KK		T.V.
LPTR		T.V.
N		T.V.
NCQQ	/LYTD/	NA
NLYR	FP	Number of compacted subgrade materials in array IX; equal to zero when all possibilities are exhausted.
NNAT	/LYTD/	NA
NPASS	/PASSCK/	Switch: 1 = first pass through GZCBR; perform CBR sort 2 = CBRs have been sorted; initialize variables 3 = successive call, no initialization.
NSBB	FP	Total number of compacted subgrade materials.
NSWTH		Variable for GO TO statement.
ORG		T.V.
OTEMP		T.V.
TEMP		T.V.
XMTK(20)		Internal array for ZCBR(I,1). May be reordered according to increasing CBR value.
YCBR(10,4)	/LYTD/	NA
ZCBR(10,6)	/LYTD/	Array containing compacted subgrade information. ZCBR (I,1) is the CBR for the Ith compacted subgrade.

Common Blocks

The common blocks in GZCBR are LYTD, CEYVAL, and PASSCK.

Tapes

None.

Traceback

GZCBR is called by LYR and calls no routines.

Illustrations

None.

References

None.

TLMC

Purpose

TLMC calculates compaction requirements of materials with design CBR values below 20 for flexible pavements.

Formal Parameters

The header card for TLMC appears as follows:

SUBROUTINE TLMC(IAIBICIDIEAB).

Description

Subroutine TLMC returns the total depth of flexible pavement materials with design CBR values below 20 needed for compaction requirements. The traffic area (A-D), load category (light, medium, heavy), cohesion, and percent of maximum density are considered in finding the depth of compaction.

Variables

Variable	Location	Usage
A	FP	Material's percent of maximum density.
B	FP	Depth of compaction of material; determined in feet and converted to inches.
DSL		Lower index for percent of maximum density.
IA	FP	Load category: 1 - light load 2 - medium load 3 - heavy load.
IB	FP	Traffic area: 1 - A 4 - D 2 - B 5 - Access aprons 3 - C 6 - Shoulders.
IC	FP	Cohesion index: 2 or 4 = cohesive.

Variable	Location	Usage
ID	FP	Upper index for percentage of maximum density.
FE	FP	Lower index for percentage of maximum density.

%	ID	FE
100	1	1
95-99	2	1
90-94	3	2
85-89	4	3
80-84	5	4
79	5	5.

TCOMC(6,6,5)		Required depth of compaction, in feet, for cohesive materials.
TCOMP(6,6,5)		Required depth of compaction, in feet, for cohesionless materials.
TLL		Depth of compaction, in feet.
TLU		Depth of compaction, in feet.
TYPBC(6,5)		Required depth of compaction, in feet, for cohesive materials, traffic area type B, access aprons, and wash racks.
TYPBS(6,5)		Required depth of compaction, in feet, for cohesionless materials, traffic area type B, access aprons, and wash racks.

Common Blocks

None.

Tapes

The tape used in TLMC is:

TAPE8--writes an error message to user.

Traceback

Subroutine TLMC is called by LYR and calls the inline function FLOAT.

Illustrations

Table D1 is the table of compaction requirements.

References

Airfield Flexible Pavements--Air Force, TM-5-824-2, Chapter 2, Table I, (Department of the Army, February 1969).

Table D1

Compaction Requirements for Types A, B, C, and D Traffic Areas (Table I, TM 5-824-2)

Material	
	Percentage Compaction of Materials With Design CBR Values of 20 and Above
Base course	Maximum density that can be obtained, generally in excess of 100% of CE 55 maximum density and never less than 100%. Type A traffic areas and center 75 ft. of runways for heavy- and medium-load pavements shall be proof-rolled.(1)
Subbase and subgrade	100% CE 55 maximum density except where it is known that a higher density can be obtained practically, then the higher density will be required.
	Percentage Compaction of Materials With Design CBR Values Below 20
Select material and subgrade in fills	Select material and subgrade in fills shall have densities equal to or greater than the values listed below. Cohesionless fill will not be placed at less than 95% nor cohesive fill at less than 90%.
Subgrade in cuts	Subgrade in cuts shall have natural densities equal to or greater than the values listed below. When they do not, the subgrade shall be (a) compacted from the surface to meet the densities listed below, (b) removed and replaced (then the requirements given above for fills apply), or (c) covered with sufficient select material subbase and base so that the uncompacted subgrade will be at a depth where the in-place densities are satisfactory.

Depth of compaction, feet, for percent CE 55 maximum density shown

Cohesionless materials

Type of assembly	Gear load, kips	100 A(2)	100 B	100 C	100 D	95 A	95 B	95 C	95 D	90 A	90 B	90 C	90 D	85 A	85 B	85 C	85 D
Heavy-load pavements Twin-twin, bicycle; spacing, 37-62-37 in. c-c; contact area, 267 sq. in.	(3)160		3.0				5.5				8.0				10.0		
	265	4.5	4.0	3.5	2.0	8.0	7.5	6.5	4.0	11.5	10.5	9.0	5.5	14.0	13.0	11.0	6.5
Medium-load pavements Twin, tricycle; spacing, 37 in. c-c; contact area, 267 sq. in.	(3)80		2.5				4.0				5.5				7.5		
	100	3.0	2.5	2.0		5.0	4.5	3.5		7.0	6.5	5.5		9.5	8.5	7.0	
Light-load pavements Single wheel, tricycle; contact area, 100 sq. in.	(4)20		1.5				2.0				3.0				3.5		
	25		1.5	1.0			2.5	2.0			3.5	3.0			4.0	3.5	

Cohesive materials

Type of assembly	Gear load, kips	100 A	100 B	100 C	100 D	95 A	95 B	95 C	95 D	90 A	90 B	90 C	90 D	85 A	85 B	85 C	85 D	80 A	80 B	80 C	80 D
Heavy-load pavements Twin-twin, bicycle; spacing, 37-62-37 in. c-c; contact area, 267 sq. in.	(3)160		1.5				3.0				4.0				5.5				7.0		
	265	2.5	2.5	2.0	1.5	4.5	4.0	3.5	2.0	6.5	6.0	5.0	3.0	8.5	8.0	6.5	4.0	10.5	9.5	8.0	4.5
Medium-load pavements Twin, tricycle; spacing, 37 in. c-c; contact area, 267 sq. in.	(3)80		1.5				2.5				3.0				4.5				5.0		
	100	2.0	1.5	1.5		3.0	2.5	2.0		4.0	3.5	3.0		5.5	5.0	4.0		6.5	6.0	5.5	
Light-load pavements Single wheel, tricycle; contact area, 100 sq. in.	(4)20		1.0				1.5				1.5				2.0				2.5		
	25		1.0	1.0			1.5	1.5			2.0	1.5			2.5	2.0			3.0	2.5	

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(1) Proof-rolling shall consist of 30 coverages of a heavy rubber-tired roller (150-p.s.i., 30,000-lb. minimum tire load) on each layer of base where the required CBR is in excess of 50 and on the top of the layer immediately under these layers.
(2) A, B, C, and D indicate traffic area types (see TM 5-824-1/AFM 88-6, Chap.).
(3) Access aprons and washracks.
(4) Washrack pavements.

TLMM

Purpose

TLMM determines the minimum thickness for pavement and base for airfield flexible pavements.

Formal Parameters

The header card for TLMM appears as follows:

SUBROUTINE TLMM(IAIBICIEIDB)

Description

Subroutine TLMM determines the minimum thickness of flexible pavement and base for airfield design from traffic area, load category, and CBR of the base. The minimum thickness table is shown in Table D2.

Variables

Variable	Location	Usage
B	FP	Minimum thickness of pavement or base of flexible pavement.
BMT(3)		Array of base minimum thicknesses (M).
IA	FP	Load category code: 1 - light load 2 - medium load 3 - heavy load.
IB	FP	Traffic area: 1 - A 4 - D 2 - B 5 - access aprons 3 - C 6 - shoulders.
IC	FP	Index designating CBR of base: 1 - 100 2 - 80.
ID	FP	Index designating whether material is pavement or base: 1 - pavement 2 - base.

Variable	Location	Usage
IE	FP	Index designating CBR of layer beneath base course: 1 <80 2 =80.
PMT1(3,6)		Minimum thickness (inches) for pavement with base of 100 CBR.
PMT2(3,6)		Minimum thickness (inches) for pavement with base of 80 CBR.

Common Blocks

None.

Tapes

The tape used in TLMM is:

TAPE8--writes error message to user.

Traceback

Subroutine TLMM is called by LYR, OVTHK, and MOAC.

Illustrations

Table D2 is the minimum thickness table.

References

Airfield Flexible Pavements--Air Force, TM 5-824-2, Chapter 2, Table II, (Department of the Army, February 1969).

Table D2

Pavement and Base Thickness Design Criteria (Table II, TM 5-824-2)

Heavy-load Design

Twin-twin assembly, bicycle; spacing, 37-62-37 in. center-to-center; contact area, 267 sq. in. each wheel

	Minimum thickness, in.(1)					
	100-CBR base			80-CBR base(2)		
Traffic area	Pavement	Base	Total	Pavement	Base	Total
A	5	10	15	6	9	15
B	4	9	13	5	8	13
C	4	9	13	5	8	13
D	3	6	9	3	6	9
Access approns(3)	3	6	9	3	6	9
Shoulders	2	6	8	2	6	8

Medium-load Design

Twin assembly, tricycle; spacing 37 in. center-to-center; contact area, 267 sq. in. each wheel

	Minimum thickness, in.(1)					
	100-CBR base			80-CBR base(4)		
Traffic area	Pavement	Base	Total	Pavement	Base	Total
A	4	6	10	5	6	11
B	3	6	9	4	6	10
C	3	6	9	4	6	10
Access aprons	3	6	9	3	6	9

Light-Load Design

Single wheel, tricycle; contact area, 100 sq. in.

	Minimum thickness, in.(1)					
	100-CBR base			80-CBR base(5)		
Traffic area	Pavement	Base	Total	Pavement	Base	Total
B	3	6	9	4	6	10
C	3	6	9	3	6	9
Access aprons	3	6	9	4	6	10

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(1) These minimum thicknesses apply when layer directly under the base course has a design CBR of 50; when the underlying layer has a design CBR of 80, the minimum thickness of base course shall be 6 in.

(2) Restricted to Florida limerock except that stabilized aggregate will be permitted in type D traffic areas.

(3) Applicable in other than cold climates (see TM 5-824-1/AFM 88-6, Chap. 1).

(4) Florida limerock or stabilized aggregate permitted in types B and C traffic areas.

(5) Florida limerock or stabilized aggregate permitted.

XMSTR

Purpose

This subroutine establishes overlay strategies for input to CONSEQ.

Formal Parameters

The header card for XMSTR appears as follows:

SUBROUTINE XMSTR(XXT,CSMN,CFMN).

Description

In subroutine XMSTR, maintenance strategies are established and placed in arrays for subsequent use by CONSEQ. The strategies, overlay thicknesses, and costs are returned to XMSTR. The least cost rigid and flexible strategies are then saved. (A rigid strategy is the combination of rigid original construction and overlays of either rigid or flexible to meet the design requirements.)

Variables

Variable	Location	Usage
CFMN	FP	Discounted maintenance cost for strategies over a flexible pavement.
CSMN	FP	Discounted maintenance cost for strategies over a rigid pavement.
CSTRT(10,6)	/RDSTR/	Array containing the years of overlays for strategy I and overlay J.
FSTRT(10)	/RLSVK/	Array containing the years of overlays for a flexible strategy.
FTMO(10,4)	/RLSVK/	Array containing overlay information for strategies over a flexible pavement: FTMO(I,1): 1 - rigid overlay 2 - flexible overlay FTMO(I,2): overlay thickness (in.) FTMO(I,3): 2 - partial bond 3 - unbonded FTMO(I,4): XK - subgrade modulus AXK - effective subgrade modulus over asphalt.

Variable	Location	Usage
I		T.V.
ICOUNT	/RESTR/	Overlay strategy number.
ID	/DOBK/	Index for CALCULATION.TYPE: 1 = maintenance 2 = life cycle 3 = design.
IMAN	/RDSTR/	NA
IREST	/RESTR/	Index for DESIGN.RESTRICTION: 1 = none 2 = rigid 3 = flexible.
J		T.V.
JRESTQ	/RESTR/	NA
K		T.V.
LBAD		Counter for the number of overlays which have service lives less than or equal to the time of the first overlay.
MSTRT		Number of overlays in a strategy which have service lives greater than the time of the first overlay.
NFSTRT	/RLSVK/	Number of overlays in a particular flexible strategy.
NOO(10)	/RDSTR/	Number of overlays in strategy I.
NRSTRT	/RLSVK/	Number of overlays in a particular rigid strategy.
NSTRT		Number of overlays for a particular strategy.
NSTRT1		Number of overlays in a particular rigid strategy.
NSTRT2		Number of overlays in a particular flexible strategy.

Variable	Location	Usage
NUMO		Temporary variable for the number of overlays in a particular strategy.
NUMS	/RDSTR/	NA
NXSTRT(2)	/FLSVK/	Array containing a number of overlays in a particular strategy: NXSTRT(1) - rigid strategy NXSTRT(2) - flexible strategy.
RSTRT(10)	/RLSVK/	Array containing the years of overlays for a particular rigid strategy.
RTMO(10,4)	/RLSVK/	Same as FTMO, for rigid strategies.
STRT(10)		Array containing years of overlay for overlay I.
XSTRT(2,10)		Array containing the years of overlays for a particular strategy: XSTRT(1,J) - rigid strategy XSTRT(2,J) - flexible strategy.
XTMO(2,10,4)	/FLSVK/	Array containing overlay information: XTMO(1,IJ) - same as RTMO(IJ) XTMO(2,IJ) - same as FTMO(IJ).
XXT	FP	Service life of original construction.

Common Blocks

The common blocks for XMSTR are:

DOBK, FLSVK, RDSTR, RESTR, and RLSVK.

Tapes

The tape used in XMSTR is:

TAPE6 -- writes messages to the debug file.

Traceback

Subroutine XMSTR is called by PAVE and calls CONSEQ and the inline function FLOAT.

Illustrations

Figure D7 is a descriptive flowchart of XMSTR.

References

None.

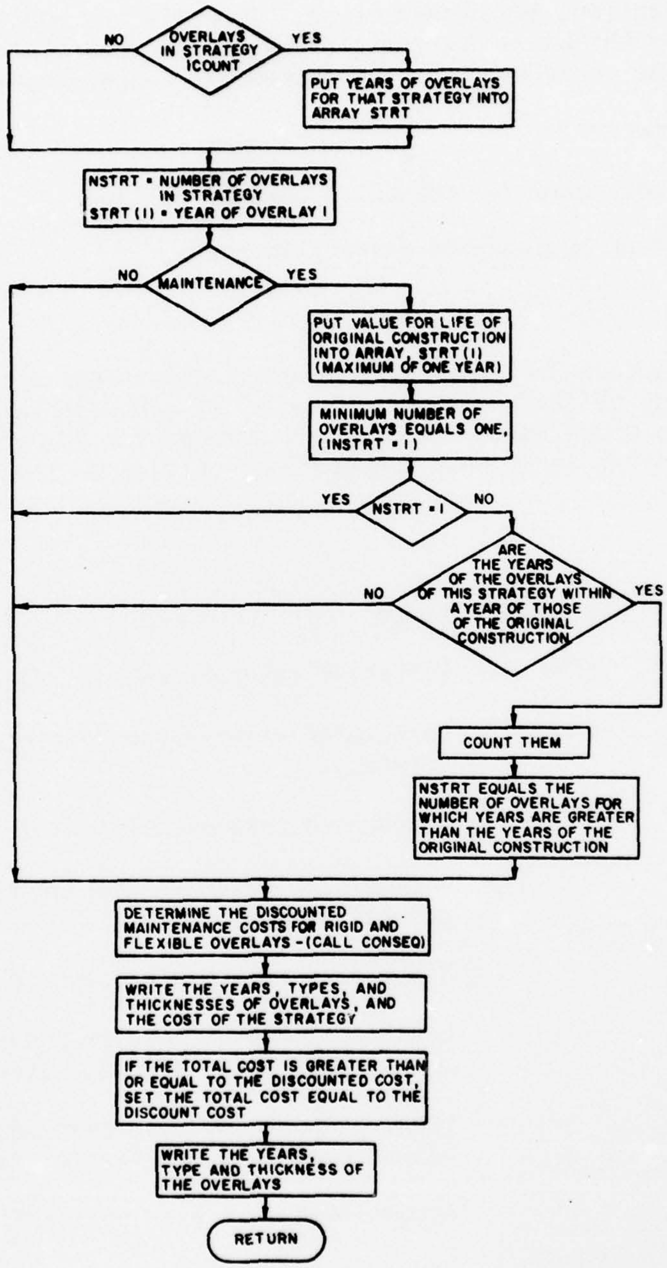

Figure D7. Descriptive flowchart of XMSTR.

CONSEQ

Purpose

This subroutine determines type of overlay, appropriate modulus of subgrade reaction, and bonding type. It calls the routines that calculate overlay thickness and costs of maintenance (vehicle and pavement) and saves the cheaptest type arrangement for each strategy.

Formal Parameters

The header card for CONSEQ appears as follows:

SUBROUTINE CONSEQ(STRT,NSTRT,CSMN,CFMN).

Description

This routine develops all possible combinations of overlays allowed in a strategy by the input. As the cost of each combination is determined, it is compared to a least cost combination and either rejected or saved as the new least cost combination. Figure D8 illustrates the procedure used.

Variables

Variable	Location	Usage
AXK	/LCY/	Effective subgrade modulus over asphalt.
CFMN	FP	Discounted maintenance cost for flexible strategy.
COM		Discounted cost of maintenance strategy.
CSM		Accumulated cost over design life plus maintenance cost.
CSMN		Discounted maintenance cost for rigid strategy.
CSN		Least accumulated cost over design life plus maintenance cost for rigid strategy.
CSP		Least accumulated cost over design life plus maintenance cost for flexible strategy.
CTU		Accumulated cost over design life.
DHD	/FMBLK/	Pavement thickness.

Variable	Location	Usage
DT	/DOBK/	DTHICKNESS (pavement plus base).
DT2Q	/DOBK/	NA
I		T.V.
IA(6)		Array containing index for overlay type for each overlay (see IA1-IA6): 1 = rigid 2 = flexible.
IAXK	/KAYBK/	Index for RIGID.ON.FLEX: 1 = yes (internal default) 2 = no.
IA1		Index for overlay type for sixth overlay: 1 = rigid 2 = flexible.
IA2		Index for overlay type for fifth overlay: 1 = rigid 2 = flexible.
IA3		Index for overlay type for fourth overlay: 1 = rigid 2 = flexible.
IA4		Index for overlay type for third overlay: 1 = rigid 2 = flexible.
IA5		Index for overlay type for second overlay: 1 = rigid 2 = flexible.
IA6		Index for overlay type for first overlay: 1 = rigid 2 = flexible.
IB(6)		Array containing index for overlay type for each overlay (see IB1-IB6): 1 = rigid 2 = flexible.

Variable	Location	Usage
IBN	/AMBLK/	Index identifying bonding characteristics: 2 = partial 3 = unbonded 4 = both.
IB1		Index for overlay type for sixth overlay: 1 = rigid 2 = flexible.
IB2		Index for overlay type for fifth overlay: 1 = rigid 2 = flexible.
IB3		Index for overlay type for fourth overlay: 1 = rigid 2 = flexible.
IB4		Index for overlay type for third overlay: 1 = rigid 2 = flexible.
IB5		Index for overlay type for second overlay: 1 = rigid 2 = flexible.
IB6		Index for overlay type for first overlay: 1 = rigid 2 = flexible.
ICNT	/CNT/	Counter for unique design scheme.
ICONT	/COUNT/	Initialized to 0.
ICOUNT	/RESTR/	Overlay strategy number.
ID	/DOBK/	Index for CALCULATION.TYPE: 1 = maintenance 2 = life cycle 3 = design.
IDF	/RODLOD/	DESIGN.INDEX for flexible pavement (1-10).
IDI		DESIGN.INDEX (1-10).
IDR	/RODLOD/	DESIGN.INDEX for rigid pavement (1-10).

Variable	Location	Usage
IIX(10,10)	/FMBLK/	Identifies the layers used in a unique flexible design scheme: IIX(1,J) is the number of layers in design scheme J, plus one. IIX(IJ) is the number of the (I-1) layer for scheme J.
IMAN	/RDSTR/	Index for GENERATE.STRATEGIES: 1 = yes 2 = no (internal default).
IREST	/RESTR/	Index for DESIGN.RESTRICTION: 1 = none 2 = rigid 3 = flexible.
ITP(6)		Array containing index for rigid or flexible overlay: 1 = rigid 2 = flexible.
ITY	/DOBK/	Index for design type (DTYPE): 1 = rigid 2 = flexible.
IX		Index for rigid-flex-rigid combination when equal to 2.
I1		T.V.
I2		T.V.
I3		T.V.
I4		T.V.
I5		T.V.
I6		T.V.
J		T.V.
JBN		T.V. for indicating bonding characteristics 2 = partial 3 = unbonded 4 = both.

Variable	Location	Usage
JREST		Index for OVERLAY.RESTRICTION: 1 = none 2 = rigid 3 = flexible.
KBN		T.V. for indicating bonding characteristics (see JBN).
KK		T.V.
L		T.V.
LIMT	/XMBLK/	Index indicating the number of possible original pavement types (rigid and/or flexible).
LLIT		T.V.
LM		T.V.
LMIT		T.V. for the number of flexible layers.
LN		T.V.
LZ	/RODLOD/	NA
M		T.V.
MNTO	/SZBK/	NA
MXN	/AMBLK/	Maximum number of overlays allowed within a strategy.
MXTOQ	/SZBK/	NA
NBX		Difference between the number of overlays and the maximum number of overlays (6).
NODQ	/NBLK/	NA
NOGQ	/NBLK/	NA
NOHQ	/NBLK/	NA
NOSGQ	/NBLK/	NA
NPTQ	/NBLK/	NA

Variable	Location	Usage
NSTRT	FP	Number of overlays in a particular design.
NUMS	/RDSTR/	NA
NX		Counter for unique design schemes.
NXQ	/NBLK/	NA
NXSTRT(2)	/FLSVK/	Array containing number of overlays in a particular strategy: NXSTRT(1) - rigid strategy NXSTRT(2) - flexible strategy.
NXX		T.V. for IIX(I,J).
NYQ	/NBLK/	NA
STRT(10)	FP	Array containing years of overlay for overlay I.
THK(10,10)	/FMBLK/	Array containing layer thickness: THK(1,J) is the rigid pavement thickness for unique design scheme J THK(I,J) is the (I-1) flexible layer thickness for scheme J.
TMO(10,4)		Array containing overlay information: TMO(I,1): 1 = Ith overlay is rigid 2 = Ith overlay is flexible. TMO(I,2): overlay thickness in inches. TMO(I,3): 2 = partially bonded rigid overlay 3 = unbonded rigid overlay. TMO(I,4): XK, the subgrade modulus, except for rigid overlays over asphalt, then AXK, the effective modulus.
T1	/T1BK/	Base thickness.
XK	/NBLK/	Subgrade modulus, pci.
XSTRT(2,10)	/FLSVK/	Array containing the years of overlays for a particular strategy: XSTRT(1,J) - rigid strategy XSTRT(2,J) - flexible strategy.

Variable	Location	Usage
XTMO(2,10,4)	/FLSVK/	Array containing overlay information: XTMO(1,I,J) is TMO(I,J) for overlays over rigid pavement XTMO(2,I,J) is TMO(I,J) for overlays over flexible pavement.

Common Blocks

The common blocks in CONSEQ are:

AMBLK, CNT, COUNT, DOBK, FLSVK, FMBLK, KAYBK, LCY, NBLK, RDSTR, RESTR, RODLOD, SZBK, T1BK, XMBLK.

Tapes

The tape used in CONSEQ is:

TAPE6 - writes information to the debug file.

Traceback

Subroutine CONSEQ is called by XMSTR and calls OVTHK, MOAC, USRC, and the inline functions FLOAT and INT.

Illustrations

Figure D8 is a descriptive flowchart for CONSEQ.

References

None.

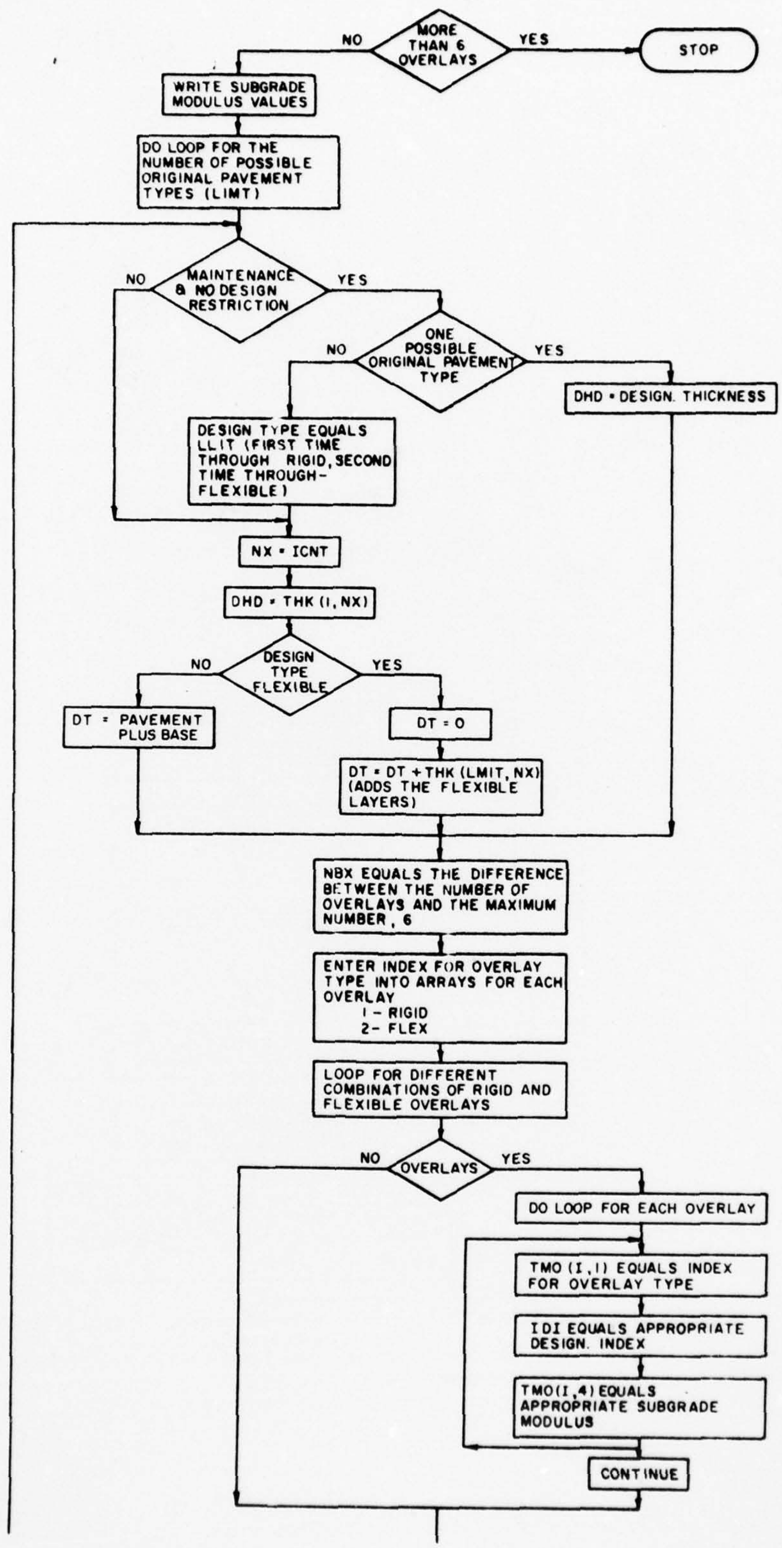

Figure D8. CONSEQ flowchart.

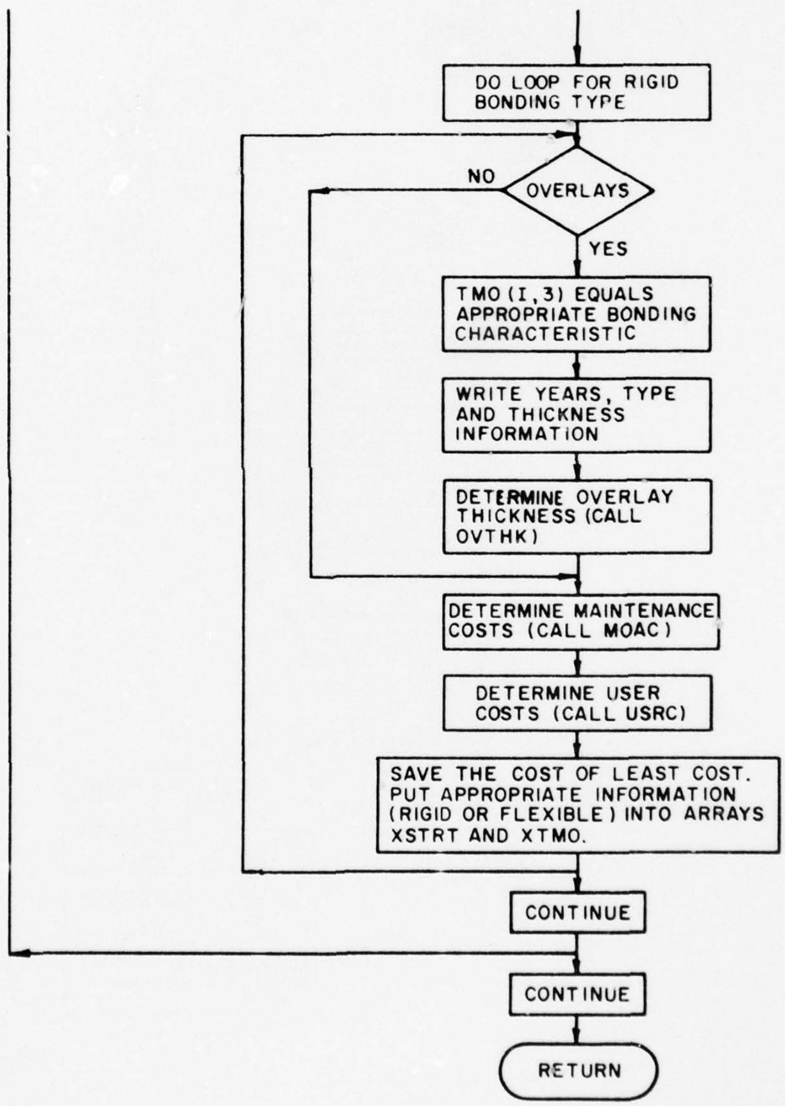

Figure D8 (cont'd).

AD-A067 691 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAI--ETC F/G 13/2
SYSTEMS APPROACH TO LIFE-CYCLE DESIGN OF PAVEMENTS. VOLUME II. --ETC(U)
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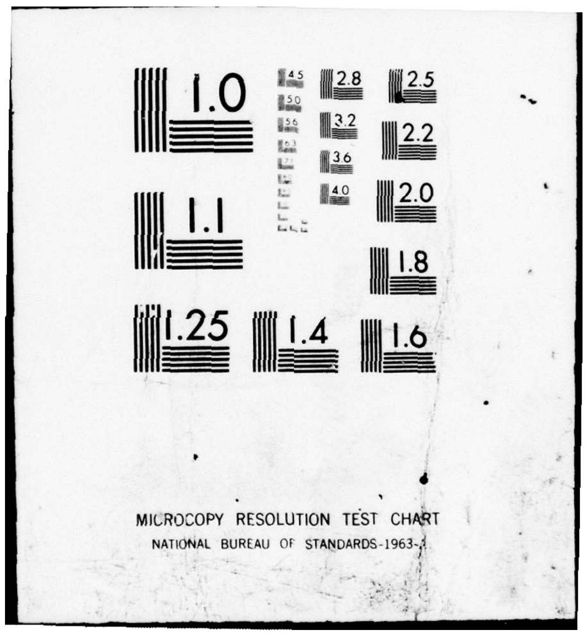
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-

OVTHK

Purpose

Subroutine OVTHK performs the calculations to determine the required thicknesses of overlays.

Formal Parameters

The header card for OVTHK is:

SUBROUTINE OVTHK(TMO,STRT,NSTRT,IDI).

Description

The formal parameters for OVTHK supply the times of overlay placement (STRT) and the design requirements (overlay type, bonding, modulus) for that strategy (TMO). With this information, the thickness of each overlay is calculated and stored. Figure D9 illustrates the OVTHK procedure.

Variables

Variable	Location	Usage
AHH(10)	/HBLK/	NA
AP		Required thickness above subgrade at a given time.
AXK	/LCY/	NA
BASET		Base thickness.
BP		Total thickness of the subgrade layers.
C		Index for CONDITION coefficient:

	rigid	flexible
INITIAL.FAILURE	.75	1.0
SHATTERED.SLAB	.50	.75
COMPLETE.FAILURE	.35	NA
GOOD.CONDITION	1.0	1.0

Variable	Location	Usage
CBRL		CBR
CP		Required thickness based on years of last overlay design.

Variable	Location	Usage
DHD	/FMBLK/	Pavement thickness.
DT	/DOBK/	DTHICKNESS (pavement plus base).
DT2Q	/DOBK/	NA
F		F-factor obtained from subroutine FF and used in the design of flexible overlays.
FACCQ	/IABLK/	NA
FACNQ	/IABLK/	NA
FACQ	/LCY/	NA
HD		Required thickness of overlay.
HH(10)	/HBLK/	NA
HHH		Difference between thickness needed and existing thickness (minimum of 1 in [25.4 mm]).
I		T.V.
IA	/IABLK/	Index for wheel type for a particular vehicle: twin tandem - 02 all others - 00.
IAXK	/KAYBK/	Index for RIGID.ON.FLEX: 1 = yes (internal default) 2 = no.
IB		Index for BONDING: 2 = partial 3 = unbonded.
IBABE		CBR of base course: 1 = 100 2 = 80 3 = 50.
IBN	/AMBLK/	NA
ICNT	/CNT/	NA

Variable	Location	Usage
ICOND	/COND/	Index for CONDITION: 1 = GOOD.CONDITION 2 = INITIAL.FAILURE 3 = SHATTERED.SLAB 4 = COMPLETE.FAILURE.
ICOUNT	/RESTR/	NA
ID	/DOBK/	Index for CALCULATION.TYPE: 1 = maintenance 2 = life cycle 3 = design.
IDI	FP	DESIGN.INDEX (1-10).
IDR	/RODLOD/	NA
IFCON	/FCON/	Index for INITIAL.FAILURE: 1 = no 2 = yes.
IIX(10,10)	/FMBLK/	NA
IMAN	/RDSTR/	NA
IPBQ		Index for material type: 1 = pavement 2 = base.
IRESTQ	/RESTR/	NA
ISB		CBR of underlying material: 1 = 80 2 = 100.
ISYS		Type (ITY) of overlay system involved in calculations: 1 = rigid 2 = flexible.
ITY		Index for design type (DTYPE): 1 = rigid 2 = flexible.

Variable	Location	Usage
ITYPN		Type of overlay: 1 = rigid 2 = flexible.
JCOND	/FLAG/	Flag, when equal to 2, for a flexible overlay on a completely failed pavement which causes an informative message to be printed by PROGRAM RL.
JDL	/SCAN3/	Design life of the pavement in years.
JJ		T.V.
JRESTQ	/RESTR/	NA
KK		Number of coordinates of input cost data.
KLASS		Load category (LFUNC).
LDF	/RODLOD/	NA
LFUNC	/TYPBK/	Load category based on traffic area or class of road: 1 = A 4 = D 1 = light 3 = C 6 = F.
LMH	/TYPBK/	Index for load category: 1 = light 2 = medium 3 = heavy.
LS	/LCM/	Number of times at which calculations are performed.
LTQ	/IABLK/	NA
LZ	/RODLOD/	Indicates roadway design when equal to 3.
MNTO	/SZBK/	NA
MXN	/AMBLK/	NA
MXTO	/SZBK/	NA
NB	/LYTD/	NA

Variable	Location	Usage
NCOM	/LYTD/	NA
NNAT	/LYTD/	Number of natural layers.
NODQ	/NBLK/	NA
NOGQ	/NBLK/	NA
NOH	/NBLK/	NA
NOSGQ	/NBLK/	NA
NPTQ	/NBLK/	NA
NSBB	/LYTD/	NA
NSTRT	FP	Number of overlays in a particular strategy.
NXQ	/NBLK/	NA
NYQ	/NBLK/	NA
OMTF	/MTO/	MINIMUM.THICKNESS.FLEXIBLE.OVERLAY.
OMTR	/MTO/	MINIMUM.THICKNESS.RIGID.OVERLAY.
OTH		Overlay thickness.
STRT(10)	FP	Array containing years of overlays.
THFF(20)	/THKBK/	Array containing required thicknesses at given times for flexible layers.
THIKENS		Pavement thickness (inches).
THK(10,10)	/FMBLK/	NA
THL		Thickness of last overlay or design.
THO		Difference between required thickness and design thickness.
TL		Time to end of last overlay design.
TLFT		Time difference between last overlay and overlay being calculated.

Variable	Location	Usage
TLIM		Minimum thickness of pavement for flexible pavement.
TM(20)	/HBLK/	Array containing the years at which the program calculates pavement thicknesses (not to be confused with TIMES.OF.OVERLAY).
TMO(10,4)		Array containing overlay information: TMO(I,1): 1 = Ith overlay is rigid 2 = Ith overlay is flexible. TMO(I,2): overlay thickness in inches. TMO(I,3): 2 = partially bonded rigid overlay 3 = unbonded rigid overlay. TMO(I,4): XK, the subgrade modulus, except for rigid overlays over asphalt, then AXK, the effective modulus.
TN		Time to end of overlay being calculated.
TRA(20)	/BMBLK/	NA
TRAA(20)	/BMBLK/	NA
TRKK(20)	/THKBK/	Required thickness for rigid pavement.
TRYQ(20)	/LCY/	NA
TTHS		DT (DESIGN.THICKNESS).
XK	/NBLK/	NA
XMT(10,6)	/LYTD/	NA
YAK		Subgrade modulus for existing pavement.
YCBR(10,4)	/LYTD/	Array containing characteristics of the subgrade layers: YCBR(I,1) - CBR YCBR(I,2) - Density YCBR(I,3) - Thickness YCBR(I,4) - Cohesion 1 - cohesionless 2 - cohesive.
YKQ	/LCY/	NA

Variable	Location	Usage
ZCBR(10,6)	/LYTD/	NA
ZMT(3,4)	/LYTD/	NA

Common Blocks

The common blocks in OVTHK are:

AMBLK, BMBLK, CNT, COND, DOBK, FCON, FLAG, FMBLK, HBLK, IABLK, KAYBK, LCY, LYTD, MTO, NBLK, RDSTR, RESTR, RODLOD, SCAN3, SZBK, THKBK, TYPBK.

Tapes

The tape used by OVTHK is:

TAPE6 - writes to the debug file.

Traceback

Subroutine OVTHK is called by CONSEQ and calls FF, GINT, MTHICK, RDO, SQRT (CDC library), and TLMM.

Illustration

Figure D9 is a descriptive flowchart of OVTHK.

References

Airfield Flexible Pavements -- Air Force, TM 5-824-2 (Department of the Army, 7 February 1969).

Rigid Pavements for Airfields Other than Army, TM 5-824-3 (Department of the Army, 7 December 1970).

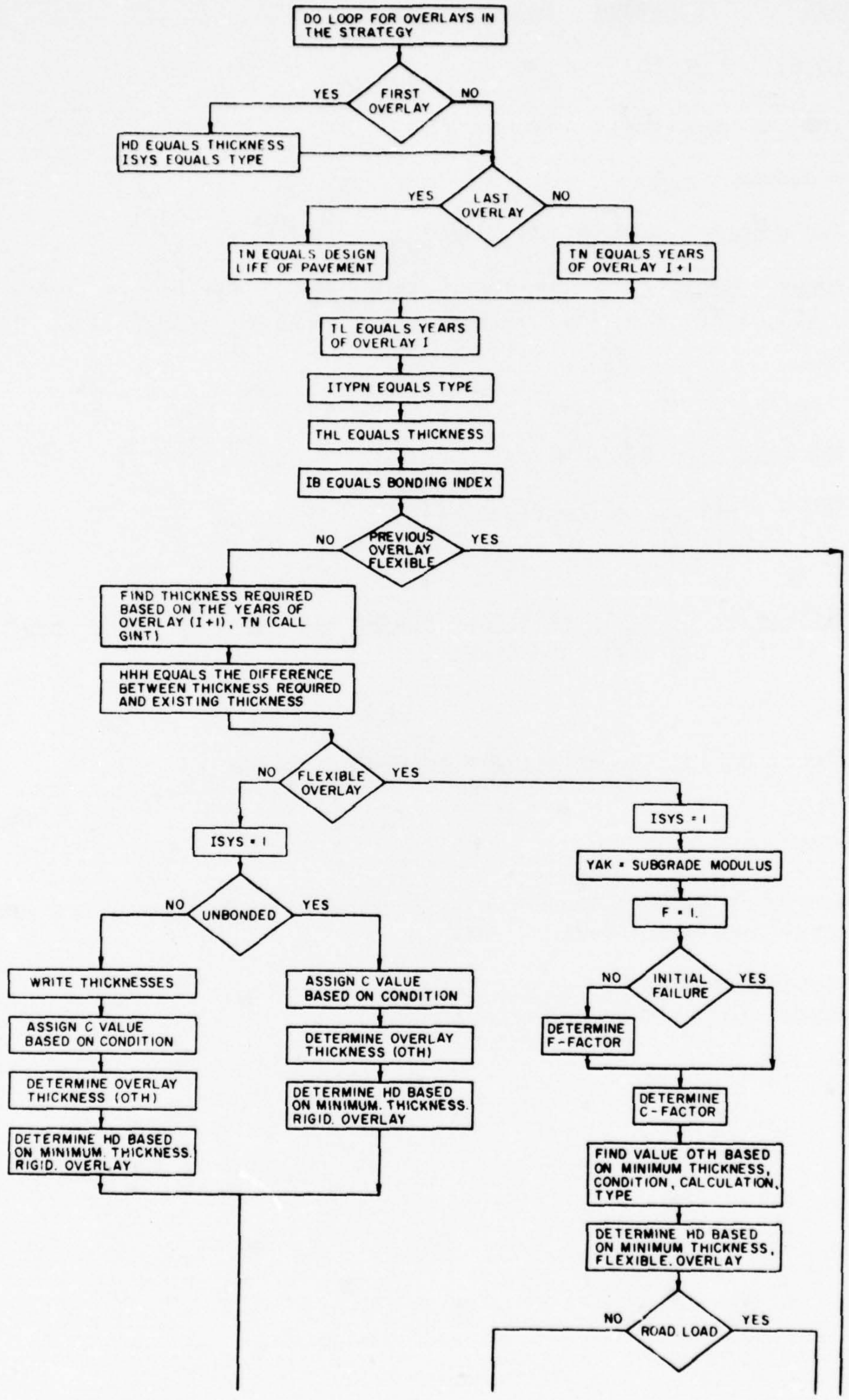

Figure D9. OVTHK flowchart.

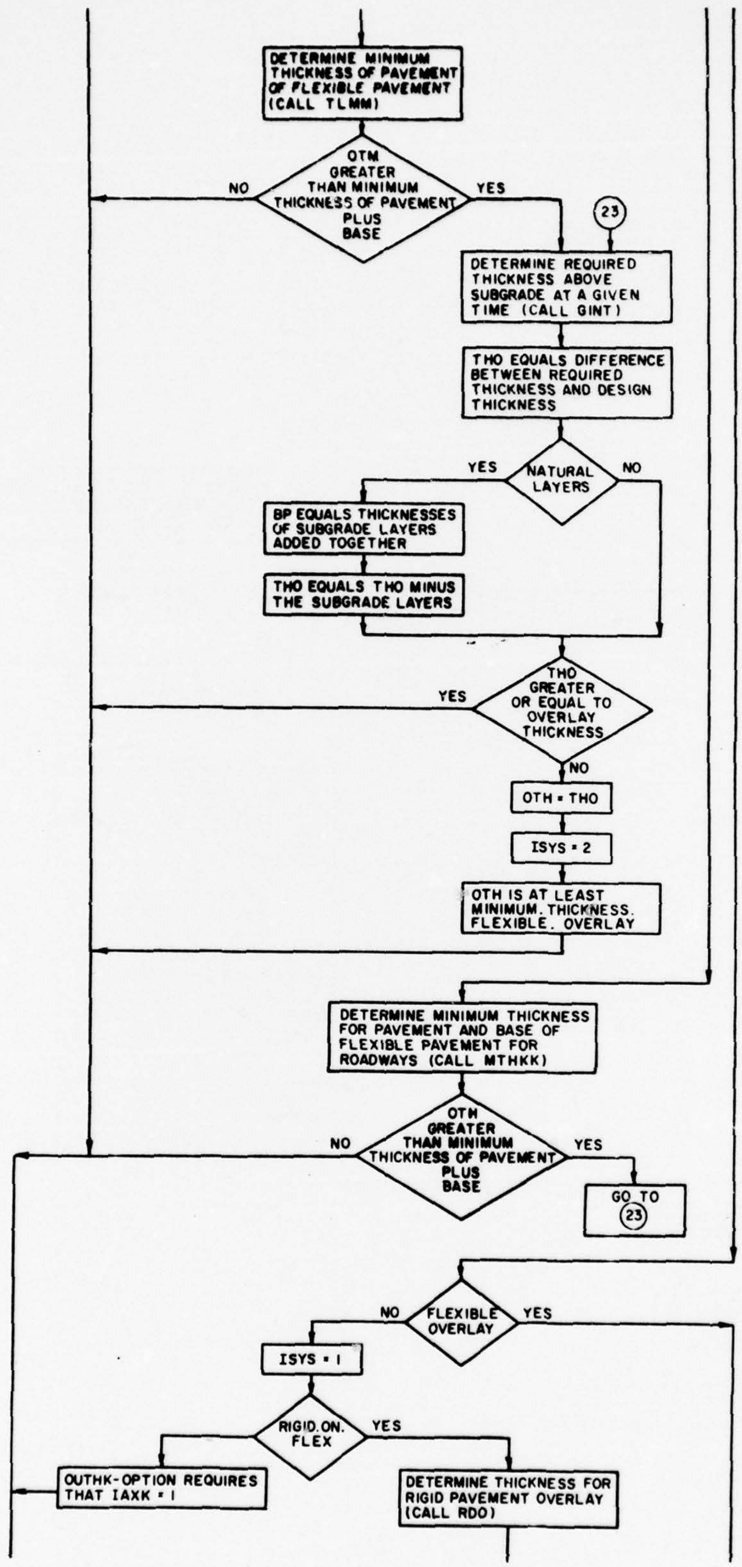

Figure D9 (cont'd).

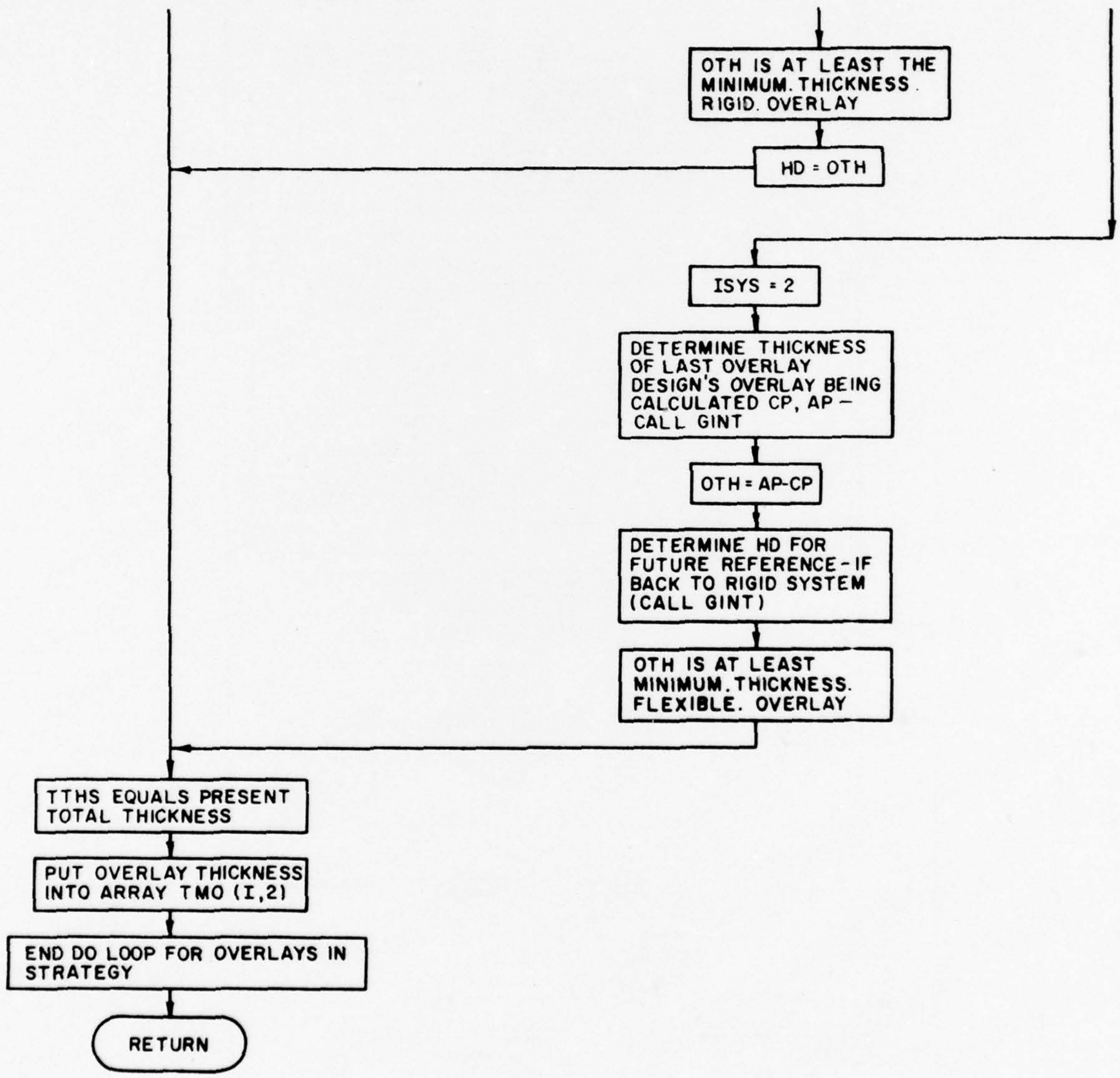

Figure D9 (cont'd).

EXCOST3

Purpose

Subroutine EXCOST3 is used for computation of earthwork costs.

Formal Parameters

The header card for EXCOST3 is:

SUBROUTINE EXCOST3(BSTK,TPAV).

Description

Subroutine EXCOST3 calculates the total cost of earthwork based on the volume of earth to be moved and the unit cost ($/cu yd). It uses the average end area to calculate the volume. End areas calculated for a zero pavement thickness in OVERLAY (4,0) are read from TAPE2. These areas are changed according to the design pavement thickness. The volume between the end areas is calculated and the costs computed.

Variables

Variable	Location	Usage
A		End area (sq yd) for zero thickness pavement.
APREND(9,3)	/ZONES/	NA
APRSTR(9,3)	/ZONES/	NA
APTOT	/ZONES/	Total cost of approach work.
APWID(9)	/ZONES/	NA
B		End area (sq yd) for zero thickness pavement.
BSTK	FP	Base thickness (inches).
CUT		Volume of cut (cu yd).
CUTCOST	/TSV/	Total cost of cut ($).
CUTPRCE	/TSV/	Unit cost of cut ($/cu yd).
ERCOST	/TSV/	Total cost of earthwork ($).

Variable	Location	Usage
FILCST		Total cost of fill.
FILL		Volume of fill (cu yd).
FILPRCE	/TSV/	Unit cost of fill ($/cu yd).
I		T.V.
IFL		Index for end-of-file: Zero -- no end-of-file encountered Nonzero -- end-of-file encountered.
IK		T.V.
IND	/TMPL/	NA
JACK	/TMPL/	NA
NAPR	/ZONES/	NA
NERTH	/TSV/	Number of unique thicknesses.
PSTEP	/TSV/	Length of prism used in average end area volume calculations (feet).
SAVER(50,2)		Array containing costs and thicknesses: SAVER(I,1) = thickness SAVER(I,2) = cost.
SWID	/TMPL/	Width of pavement (yards).
THCK	/TSV/	Base thickness plus pavement thickness (inches).
TPAV	FP	Thickness of rigid pavement.
TWOCL	/TMPL/	NA
VOL		Volume of earthwork (cu yd).
ZONSTEP(9)	/ZONES/	NA

Common Blocks

The common blocks in EXCOST3 are:

TMPL, TSV, ZONES

Tapes

The tape used by EXCOST3 is:

TAPE2 - contains end areas for a zero thickness pavement calculated in OVERLAY (4,0).

Traceback

Subroutine EXCOST3 is called by BTCT and calls EOF and the inline function ABS.

Illustrations

None.

References

None.

DRNAGE3

Purpose

The subsurface drainage analysis is performed in subroutine DRNAGE3.

Formal Parameters

The header card for DRNAGE3 is:

SUBROUTINE DRNAGE3(BSTK,TPAV).

Description

The analysis first determines whether frost penetration or ground water depth will necessitate underdrains. In addition, it checks whether the user has specified that underdrains are required for surface flooding, a sag vertical curve, or underground seepage. If underdrains are unnecessary, the analysis is terminated, and this conclusion is printed in the program output.

If underdrains are required, the greatest depth required by frost, ground water, or user criteria is determined. Next, the pipe spacing is determined, with pipes assumed to be at both edges of the pavement. If the quantity of water exceeds pipe capacity, underdrains are placed at the pavement section's quarter points. The required pipe diameter is calculated, the construction quantities and costs are determined, and a cost per lineal foot of pipe is calculated. A cost estimate is then derived for laterals and outlets, based on user input and cost per lineal foot. Finally the total subsurface drainage cost and pertinent underdrain geometry are returned to the main program and become part of the output.

Variables

Variable	Location	Usage
ALOS	/SA/	Length of section (feet).
BSTK	FP	Base thickness.
BTE	/BSBLK/	NA
CAVCST		Unit excavation cost ($/cu yd).
CAVCSTO	/DRNBLK2/	Unit excavation cost ($/cu yd).

Variable	Location	Usage
CSTLF		Total cost per lineal foot of excavation, filter material, and pipe.
DGWT		Depth to ground water (inches).
DIP		Real value of IDIPO.
DL		Drainage length--transverse direction (feet).
DLO	/DRNBLK2/	Drainage length--transverse direction (feet).
DRAIN	/DRNBLK/	Value for DRAINAGE: 0 = no 1 = yes 2 = fixed depth.
DRNCST	/DRNBLK/	Total drainage cost.
DTP		Depth to pipe (inches).
EP		Effective porosity of base course (decimal).
EPO	/DRNBLK2/	Effective porosity of base course (decimal).
EXCAV		Volume of excavation work (cu yd).
EXCVCST		Total excavation cost ($).
FCTR		Number of drainage lines: 2 when TIME <10.0 days 4 when TIME >10.0 days.
FDE	/BSBLK/	Required depth of frost protection for FROST.DESIGN (inches).
FDEF	/BSBLK2/	Calculated depth of frost protection (inches).
FILCST		Unit filter material cost ($/cu yd).
FILCSTO	/DRNBLK2/	Unit filter material cost ($/cu yd).
FILTER		Volume of filter material (cu yd).
FMCST		Total filter material cost ($).

Variable	Location	Usage
GBM	/BSBLK/	NA
H2F		Distance from bottom of base to FDF (inches).
H2WT		Distance from bottom of base to water table (inches).
H3		Base thickness plus height of cross slope (inches) (only half of cross slope, if 50 percent drainage takes more than 10 days).
H30	/DRNBLK2/	Height of cross slope (feet).
IBTE	/BSBLK/	Index for BASE.TRADEOFF and FROST.DESIGN BASE.TRADEOFF FROST.DESIGN 1 - No No or Read 2 - unused 3 - Tradeoff No 4 - Tradeoff Read FROST 5 - Tradeoff Calculate FROST 6 - No Calculate FROST
IDGWTO	/DRNBLK2/	Depth to ground water table (inches).
IDIPO	/DRNBLK2/	User's depth to pipe (inches).
KDFLAG		Index, when greater than 0, indicates that thickness is within a foot of the water table or less than depth for frost protection.
LENGTH		Length (feet).
LENGTHO	/DRNBLK2/	Length (feet).
LOUT		Average length of outlet pipe (feet).
LOUTO	DRNBLK2	Average length of outlet pipe (feet).
NOUT		Outlet code (see NOUTO); changes to number of outlets required.

Variable	Location	Usage
NOUTO	/DRNBLK2/	Outlet code: 0 - all outlets considered 1 - all outlets drain to one side 2 - outlets drain to both sides.
PERM		Permeability of base course (ft/min).
PERMO	/DRNBLK2/	Permeability of base course (ft/min).
PIPCST		Unit cost of pipe in-place ($/lin ft).
PIPCSTO	/DRNBLK2/	Unit cost of pipe in-place ($/lin ft).
PIPECST		Unit cost of pipe ($/lin ft).
Q		Flow rate (cfs).
R		Radius of drainage pipe (inches).
RN		Manning Roughness Factor (decimal): .013 - smooth pipe .024 - corrugated pipe.
RNO	/DRNBLK2/	Manning Roughness Factor (decimal): .013 - smooth pipe .024 - corrugated pipe.
SL		Longitudinal slope (ft/ft).
SLENGTH		Length of lateral lines (feet).
SLO	/DRNBLK2/	Longitudinal slope (ft/ft).
T		Base thickness plus pavement thickness.
TIME		Time in days for 50 percent drainage.
TPAV	FP	Pavement thickness (inches)
WOS	/SA/	NA

Common Blocks

Common blocks in DRNAGE3 are:

BSBLK, BSBLK2, DRNBLK, DRNBLK2, SA.

Tapes

The tape used in DRNAGE3 is:

TAPE6 -- writes messages to debug file.

Traceback

Subroutine DRNAGE3 is called by BTCT and calls the inline functions AINT, FLOAT, IFIX.

Illustrations

Figure D10 is a flowchart of the decision criteria used in DRNAGE3.

References

Drainage and Erosion Control - Subsurface Drainage Facilities for Airfields, TM 5-820-2 (Department of the Army, August 1965).

Ernest F. Brater and Horace Williams King, *Handbook of Hydraulics*, Equation 6-26f (McGraw-Hill, Inc., 1976).

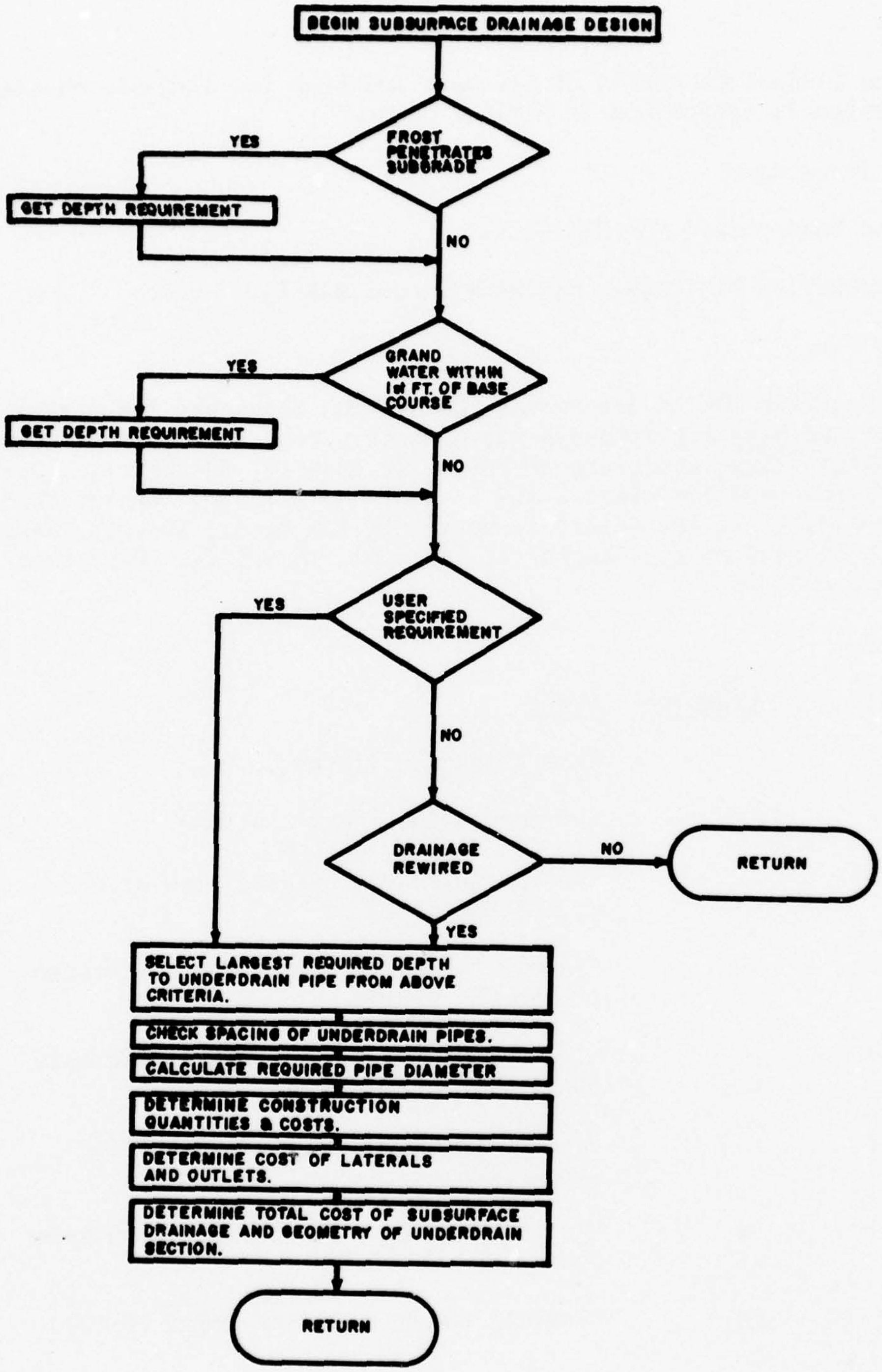

Figure D10. DRNAGE3 flowchart.

MTHICK

Purpose

The minimum thickness of pavement and base for flexible pavement in road design is determined in MTHICK.

Formal Parameters

The header card for MTHICK is:

SUBROUTINE MTHICK(DI,CBR,THIKNS,LFUNC,BASET)

Description

Subroutine MTHICK determines the minimum thickness for flexible pavement and base for roadways based on base course CBR, flexible pavement design index, and class of road. In general, 50-CBR base course will only be used for class E and F roads and streets. Design criteria used in MTHICK are from Flexible Pavements for Roads, Streets, Walks, and Open Storage Areas, Chapter 3, Table II, TM 5-822-5 (Department of the Army, June 1971).

Variables

Variable	Location	Usage
BASET		Base thickness (inches).
CBR		California Bearing Ratio, CBR.
C100B(10)		Minimum thickness of base with base course CBR of 100.
C100P(10)		Minimum thickness of pavement with base course CBR of 100.
C50P(10)		Minimum thickness of pavement with base course CBR of 50.
C80B(10)		Minimum thickness of base with base course CBR of 80.
C80P(10)		Minimum thickness of pavement with base course CBR of 80.
DI	FP	Flexible pavement design index (1-10).

Variable	Location	Usage
ICBR		Index designating CBR of base course: 1 = 100 2 = 80=99 3 = 79 and below.
ITA(6)		Character array containing class of road information.
ITEST		Index designating class of road E or F.
KLASS		Character string designating class of road.
LFUNC	FP	Class of road based on traffic intensities (A-F).
THIKNS	FP	Pavement thickness (inches).

Common Blocks

None.

Tapes

The tape used in MTHICK is:

TAPE6 -- writes message to debug file.

Traceback

Subroutine MTHICK is called by MOAC, OVTHK, and LYR.

Illustrations

Table D-3 contains the minimum pavement and base thickness information used in MTHICK.

References

Flexible Pavements for Roads, Streets, Walks, and Open Storage Areas, TM 5-822-5 (Department of the Army, June 1971).

Table D3

Minimum Thickness of Pavement and Base (Table II, TM 5-822-5)

	Minimum Base Course CBR								
	100			80			50(a)		
Design Index	Pavement in.	Base in.	Total in.	Pavement in.	Base in.	Total in.	Pavement in.	Base in.	Total in.
1	ST(b)-1/2	4	4-1/2(c)	MST(d)-1/2	4	4-1/2(c)	2	4	6
2	MST(d)	4	5(c)	1-1/2	4	5-1/2(c)	2-1/2	4	6-1/2
3	1-1/2	4	5-1/2(c)	1-1/2	4	5-1/2(c)	2-1/2	4	6-1/2
4	1-1/2	4	5-1/2(c)	2	4	6	3	4	7
5	2	4	6	2-1/2	4	6-1/2	3-1/2	4	7-1/2
6	2	4	6-1/2	3	4	7	4	4	8
7	2-1/2	4	6-1/2	3	4	7	4	4	8
8	3	4	7	3-1/2	4	7-1/2	4-1/2	4	8-1/2
9	3	4	7	3-1/2	4	7-1/2	4-1/2	4	8-1/2
10	3-1/2	4	7-1/2	4	4	8	5	4	9

(a) In general 50-CBR base course will only be used for classes E and F roads and streets.
(b) Bituminous surface treatment (spray application); assumed at 1/2 in.-thickness.
(c) Minimum total thickness of pavement plus base for classes A through D roads and streets will be 6 in.
(d) Multiple bituminous surface treatment (spray application); assumed at 1-in. thickness.

RODDENS

Purpose

The depth of compaction for select materials and subgrades is determined in RODDENS.

Formal Parameters

The header card for RODDENS is:

SUBROUTINE RODDENS(IDI,DEN,ICOH,DEP).

Description

SUBROUTINE RODDENS determines the depth of compaction (in inches) based on flexible pavement design index, cohesion index, and percent maximum density. The depth of compaction is that required for select materials and subgrades. The information used by RODDENS is taken from Figure 2 of TM 5-882-5/AFM88-7, Chapter 3, June 1971, *Flexible Pavements for Roads, Streets, Walks, and Open Storage Areas.*

Variables

Variable	Location	Usage
COM(2)		Array containing upper and lower limits of depth.
DEN	FP	Percent of maximum density.
DEP	FP	Determined depth of compaction in inches.
DOCC(10)		Required depth in inches corresponding to flexible pavement design index (cohesive, upper range).
DOCE(10)		Required depth in inches corresponding to flexible pavement design index (lower range).
DONCC(10)		Required depth in inches corresponding to flexible pavement design index (cohesionless, upper range).
I		T.V.

Variable	Location	Usage
ICOH	FP	Cohesion index: 1 or 3 - cohesionless 2 or 4 - cohesive.
IDI	FP	Flexible pavement design index (1-10).
KK		Number of data coordinates.
PRT(2)		Temporary array for PRTC(2) and PRTN(2).
PRTC(2)		Range of percent maximum density for cohesive materials.
PRTN(2)		Range of percent maximum density for cohesionless materials.
RL(2)		Temporary array for RLC(2) and RLN(2).
RLC(2)		Reference value for cohesive materials.
RLN(2)		Reference value for cohesionless materials.
S		Interpolated reference value.

Common Blocks

None.

Tapes

None.

Traceback

Subroutine RODDENS is called by LYR and calls subroutine GINT.

Illustrations

The compaction requirements modeled by RODDENS are presented in Figure D11.

References

Flexible Pavements for Roads, Streets, Walks, and Open Storage Areas, TM 5-822-5 (Department of the Army, June 1971).

COMPACTION REQUIREMENTS: PERCENTAGE COMPACTION

MATERIALS WITH DESIGN CBR VALUES OF 20 AND ABOVE

Base Courses: Maximum that can be obtained, generally in excess of 100% maximum, MIL-STD-621, Method 106.

Subbases and Subgrades: 100% of maximum, MIL-STD-621, Method 106, except where it is known that a higher density can be obtained practicably, in which case the higher density should be required.

MATERIALS WITH DESIGN CBR VALUES BELOW 20

Select Material and Subgrades in Fills: As shown below except that in no case will cohesionless fill be placed at less than 95%, nor cohesive fill at less than 90%.

Subgrade in Cuts: Must have natural densities equal to or greater than the values shown below. Where such is not the case, the subgrade must either (a) be compacted from the surface to meet the densities shown; or (b) be removed and replaced, in which case the requirements given above for fills apply; or (c) be covered with sufficient select material subbase and base so that the uncompacted subgrade is at a depth where the in-place densities are satisfactory.

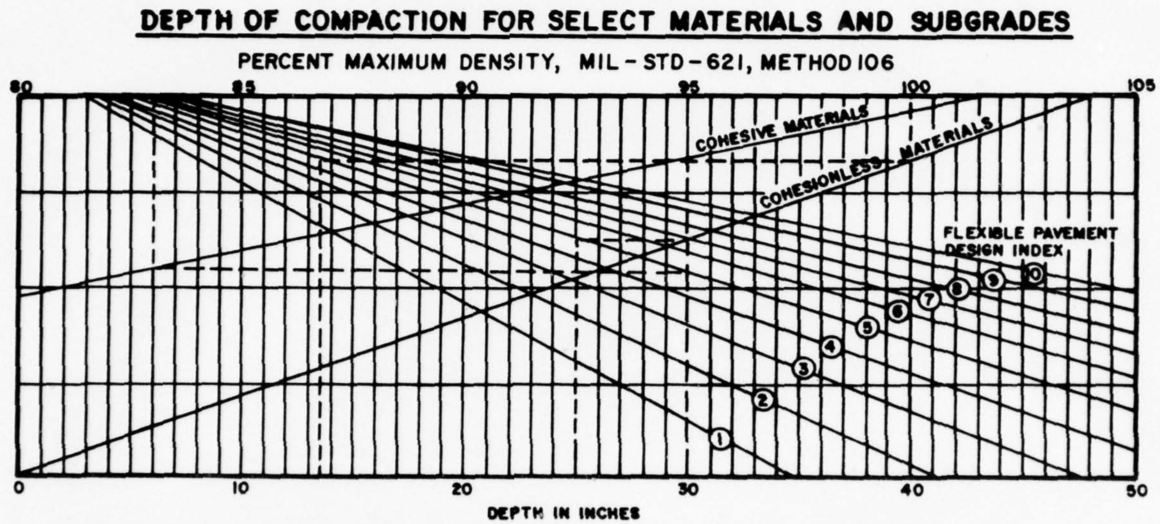

Figure D11. Compaction Requirements in RODDENS. (From Figure 2, TM 5-822-5.)

PECHART

Purpose

PECHART calculates the design factor for use in flexible pavement design.

Formal Parameters

The header card for PECHART is:

SUBROUTINE PECHART(Y,TA).

Description

SUBROUTINE PECHART determines the value for a given CBR/P_e where:

t = total thickness required above the supporting layer
A = measured contact area of tire, sq in.
P_e = ESWL (equivalent single-wheel load) or SWL (single wheel load) tire pressure, psi.

Figure D12 presents the curve modeled by PECHART.

Variables

Variable	Location	Usage
KK		Number of data coordinates
TA	FP	Determined value of
V(99)		input values corresponding to U(99).
V1(99)		input values corresponding to U1(72).
U(99)		CBR/P_e input values $\geq$ .066.
U1(72)		CBR/P_e input values $\leq$ .066.
Y	FP	Input value corresponding to CBR/P_e.

Common Blocks

None.

Tapes

None.

Traceback

Subroutine PECHART is called by PAVE and calls GINT.

Illustrations

Figure D12 presents the relationship of $t/\sqrt{A}$ to CBR/P_e used in PECHART.

References

Multiple-Wheel Heavy Gear Load Pavement Tests, Volume IV: Analysis of Behavior under Traffic, November 1971, Figure 38.

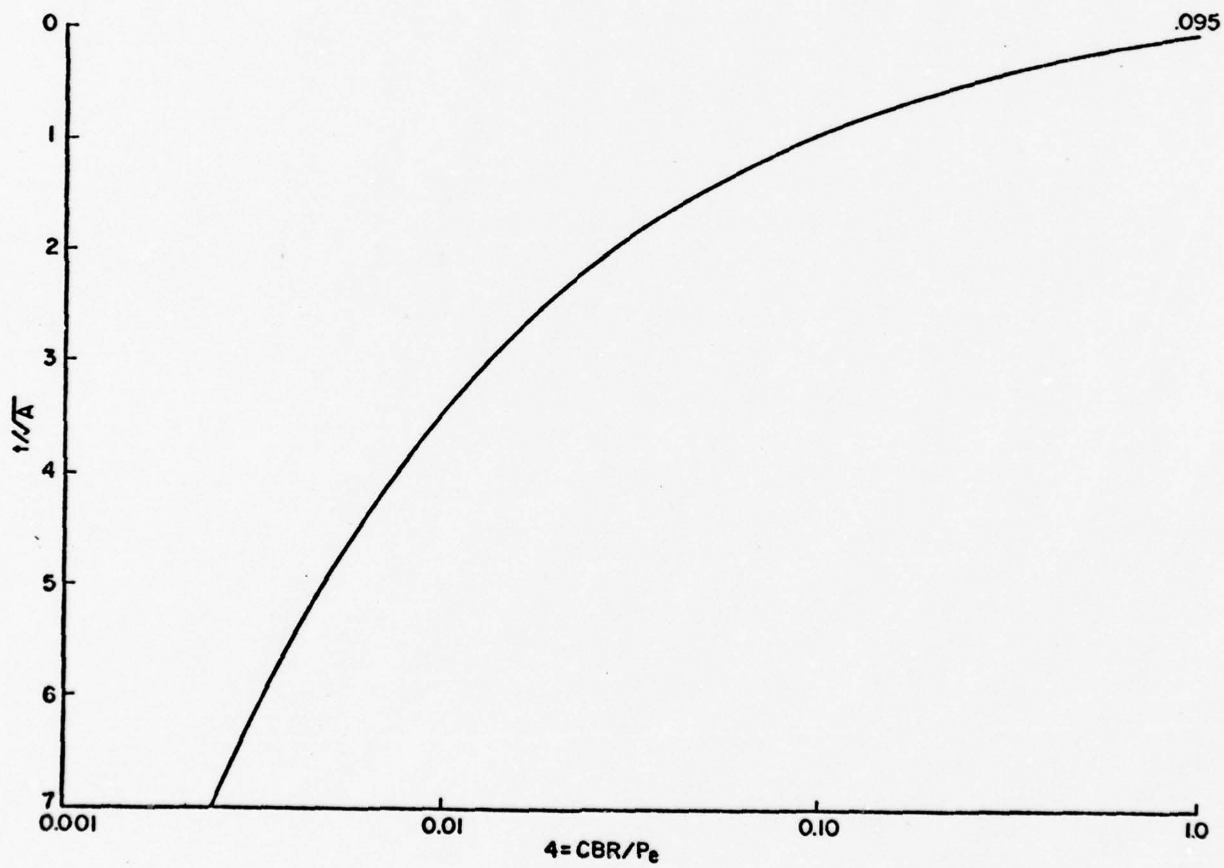

Figure D12. $t/\sqrt{A}$ vs. CBR/P_e. (From AFWL-TR-70-113).

RODTHK

Purpose

RODTHK is used to determine the percentages of the 5000 coverage design thickness required for anticipated traffic in the roadway rigid pavement analysis.

Formal Parameter

The header card for RODTHK is:

SUBROUTINE RODTHK(COVRGD,LS,TRKK).

Description

The required rigid pavement thickness for roads is determined by adjusting the slab thickness to support 5000 coverages of a basic loading to that for the design traffic coverages. The factor used for the adjustment is a percentage of the 5000 coverages thickness. The relationship of traffic coverages to this percentage factor is given in Figures D13 and D14. RODTHK models this relationship. Traffic coverages are the input to RODTHK, and the percent of the thickness for 5000 coverages is returned.

Variables

Variable	Location	Usage
COV		T.V. for COVRGD(I).
COVRGD(20)		Array containing traffic coverages.
DUM		Log of the traffic coverages.
I		T.V.
KK		Number of data coordinates.
LOGCOV(13)		Array containing the log of the traffic coverages corresponding to PCT5.
LS	FP	Number of times when thickness calculations are performed.
PCT5(13)		Array containing the percent of the 5000 coverages pavement thickness corresponding to PCT5.

Variable	Location	Usage
PERCNT5		Interpolated percent of the 5000 coverages pavement thickness.
TRKK(20)		Array containing PERCNT5.

Common Blocks

None.

Tapes

None.

Traceback

Subroutine RODTHK is called by PAVE, BTCT, and RDO. It calls GINT and ALOG (CDC Library).

Illustrations

Figures D13 and D14 present the relationship of coverages to rigid pavement thickness for roadway design as used in RODTHK.

References

Development of Rigid Pavement Thickness Requirements for Military Roads and Streets, Technical Report No. 4-18 (Corps of Engineers, Ohio River Division Laboratories, July 1961), Figures 2 and 3.

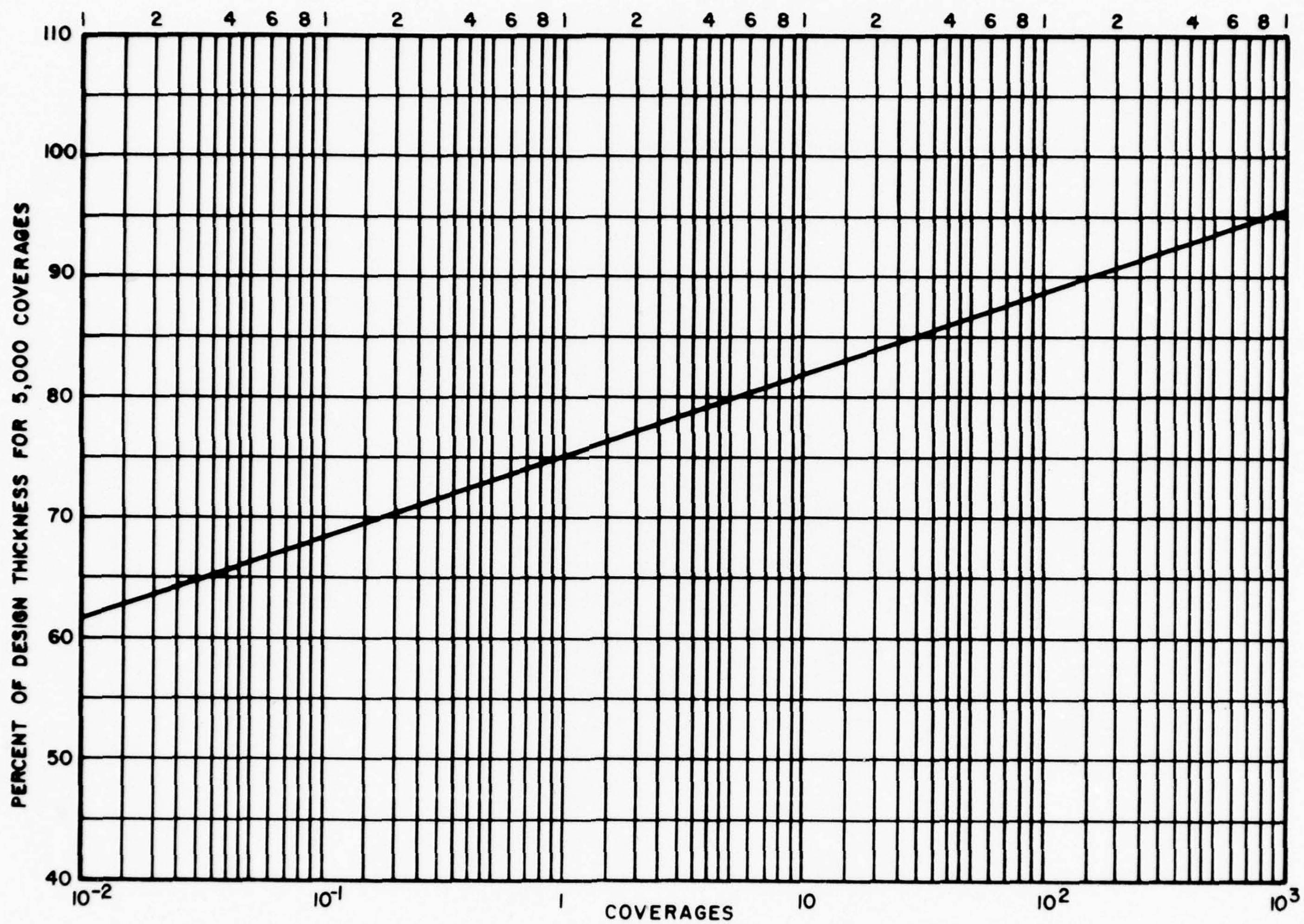

Figure D13. Coverages vs. rigid pavement thickness for military roads and streets.

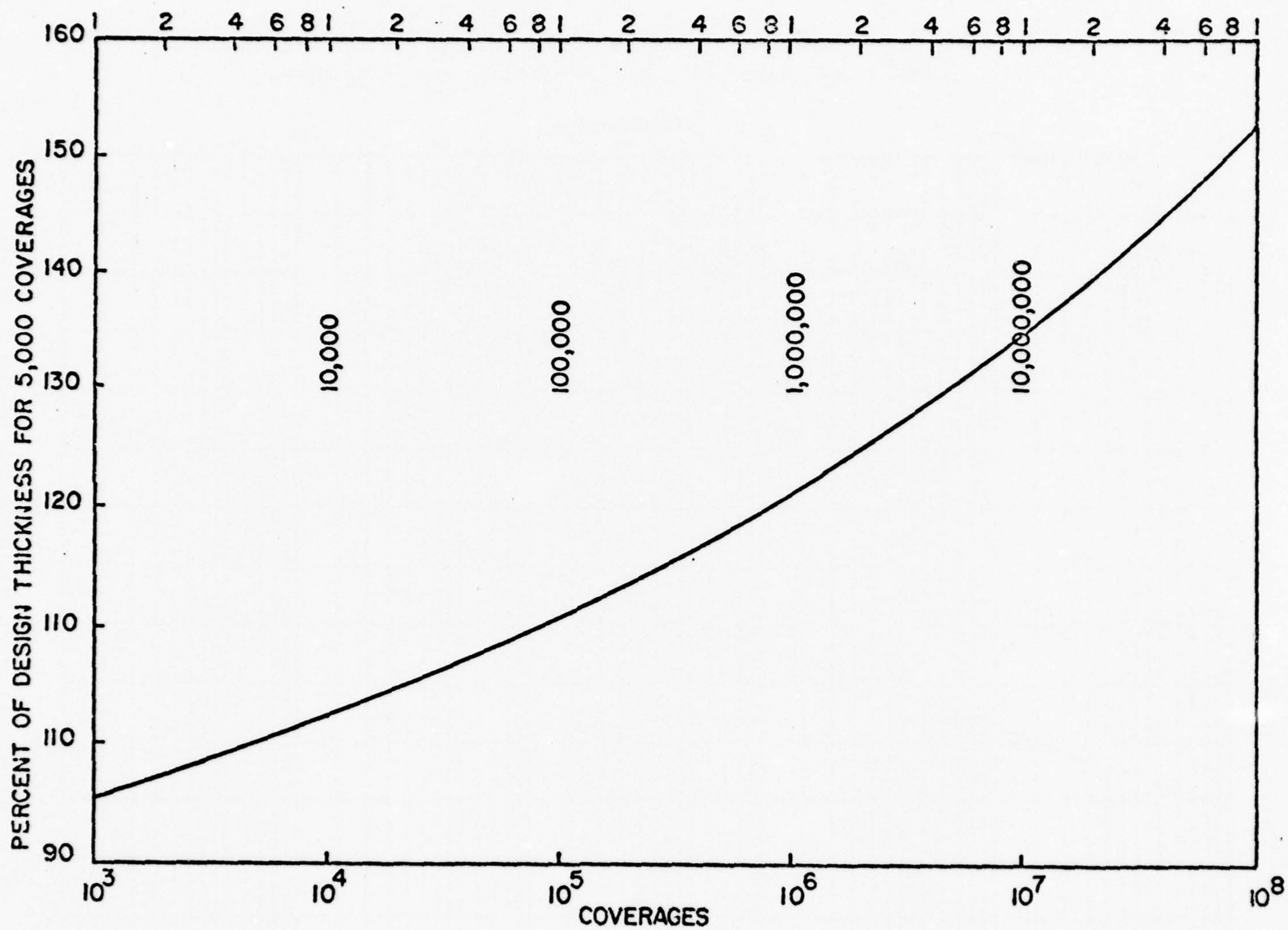

Figure D14. Coverages vs. rigid pavement thickness for military roads and streets.

FF

Purpose

The factor, F, used in the nonrigid overlay design procedure is determined by subroutine FF.

Formal Parameters

The header card for FF is:

SUBROUTINE FF(YAK,LFUNC,IA,F).

Description

The factor, F, determined in FF is used in the rigid pavement analysis to compute the required nonrigid overlay thickness from:

$$t = 2.5(Fh_d - h) \qquad \text{(Eq D1)}$$

where t = required thickness on nonrigid overlay
h_d = required equivalent slab thickness
h = existing rigid pavement thickness
F = transformation factor based on failure condition (see TM 5-824-3).

From the modulus of subgrade reaction and the area and type of traffic, F is determined from Figure D15.

Variables

Variable	Location	Usage
AK(16)		Array containing subgrade moduli values.
F	FP	Factor F interpolated from input data.
F1(16)		Array containing factor F for type A traffic area for all multiple-wheel gear designs except twin-twin wheel gear.
F2(16)		Array containing factor F for type A traffic area for twin-twin wheel gear design.
F3(16)		Array containing factor F for types B and C traffic areas for all gear designs.

Variable	Location	Usage
F4(16)		Array containing factor F for type D traffic area for twin-twin wheel gear design only.
I		T.V.
IA	FP	Index for wheel type: 1 = other 2 = twin-twin.
KK		Number of data coordinates.
LFUNC	FP	Traffic Area: 1 - A 3 - C 2 - B 4 - D
LL		Maximum/minimum number of segments.
YAK	FP	Subgrade modulus beneath existing pavement.

Common Blocks

None.

Tapes

The tape used by FF is:

TAPE6 -- writes message to debug file.

Traceback

Subroutine FF is called by OVTHK and calls GINT and the inline function FLOAT.

Illustrations

Subroutine FF models Figure D15.

References

Engineering and Design--Rigid Airfield Pavements, TM 5-824-3 (Department of the Army, February 3, 1958), Figure 15.

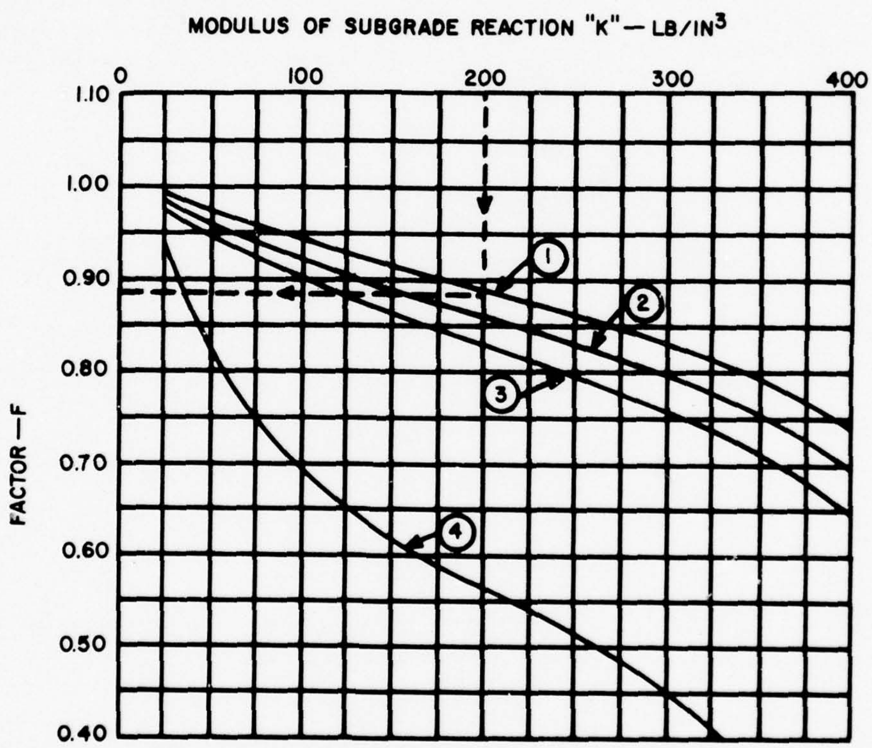

Figure D15. Procedure for determining factor F.
(From Figure 15, TM 5-824-3.)

PREVENT

Purpose

PREVENT coordinates the calculation of maintenance costs.

Formal Parameters

The header card for PREVENT is:

SUBROUTINE PREVENT(TMO,STRT,NSTRT,DTOTAL,MM).

Description

For each maintenance strategy, the maintenance costs are dependent on the pavement type (flexible or rigid) at the time of maintenance. PREVENT coordinates calls to other subroutines to calculate maintenance costs according to the pavement type and saves the total discounted maintenance cost for the strategy.

Variables

Variable	Location	Usage
DT	/DOBK/	Design thickness (DTHICKNESS).
DTOTAL	FP	Total discounted maintenance cost
DUM	/DOBK/	NA
I		T.V.
IDQ	/DOBK/	NA
IEND		Counter for years.
INDXRF(35)	/NDXRF/	Array containing overlay type for each year of overlay placement: 1 = rigid 2 = flexible 3 = no overlay in this year.
ISTART		Counter for years (IEND+1).
ITY		Index for design type (DTYPE): 1 = rigid 2 = flexible.

Variable	Location	Usage
J		T.V.
JDL	/SCAN3/	Design life of pavement in years.
KK		Counter for overlays.
L		T.V. for previous year; also used as tape number index.
MAXYR		Design life of pavement in years.
MM	FP	Variable for trial number.
NSTRT	FP	Number of overlays in a particular strategy.
STRT(10)	FP	Array containing years of overlays.
TCLNDRN		Total cost for MAINTAIN.DRAINS.
TCLNSWP		Total cost for CLEANING.SWEEPING.FLEXIBLE. PAVEMENT.
TDTOT		Total discounted maintenance cost for flexible layers.
TMO(10,4)	FP	Array containing overlay information TMO(I,1): 1 = Ith overlay is rigid 2 = Ith overlay is flexible. TMO(I,2): overlay thickness in inches. TMO(I,3): 2 = partially bonded rigid overlay 3 = unbonded rigid overlay. TMO(I,4): XK, the subgrade modulus, except for rigid overlays over asphalt, then AYK, the effective modulus.
TOTALS		Total maintenance cost.
TRKK		Total thickness of pavement overlay since first rigid overlay on pavement.
TTCRPT		Total cost for CRACKSEALING.FLEXIBLE. PAVEMENT.
TTOT		Total maintenance cost for flexible layers.

Variable	Location	Usage
TTSLCT		Total cost for SURFACE.TREATMENT.FLEXIBLE. PAVEMENT.
T1	/T1BK/	Base thickness.
XCLEAN	FP	Total cost for CLEANING.SWEEPING. RIGIDPAVEMENT.
XDISTOT	FP	Total discounted maintenance cost for rigid layers.
XREPAIR	FP	Total cost for REPAIR.SCALING.POPOUTS. RIGIDPAVEMENT.
XRESLAB	FP	Total cost for REPLACE.SLABS.RIGIDPAVEMENT.
XSLJNT	FP	Total cost for SEALING.JOINTS.CRACKS. RIGIDPAVEMENT
XTOTAL	FP	Total maintenance cost for rigid layers.

Common Blocks

The common blocks in PREVENT are:

DOBK, NCXRF, PRVNT1, SCAN3, T1BK.

Tapes

The tape used by PREVENT is:

TAPE(L) - writes summary to debug file

Traceback

Subroutine PREVENT is called by MOAC and calls RIGID, FLEXBL, and the inline function INT.

Illustrations

Figure D16 is a flowchart of subroutine PREVENT.

References

None.

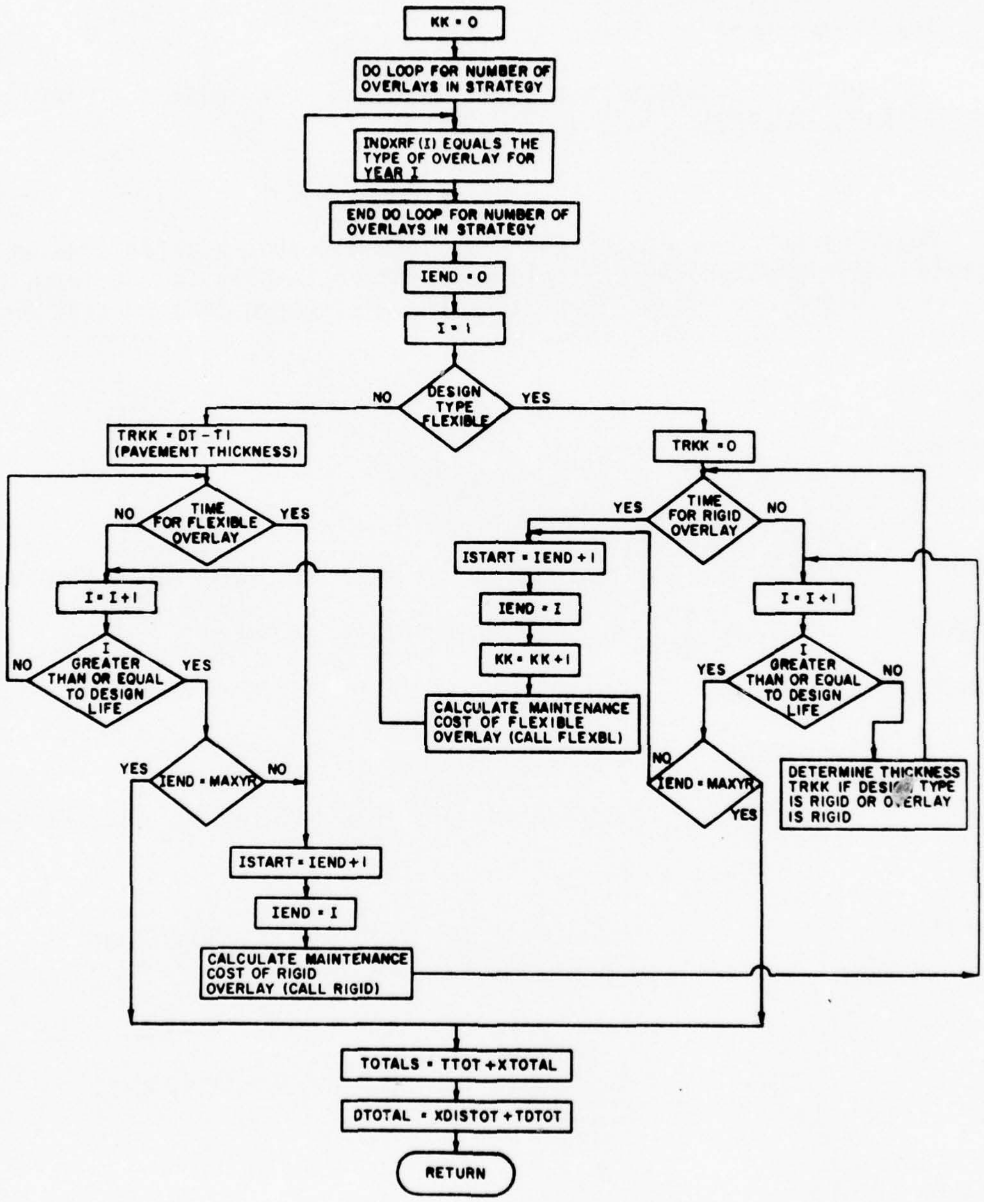

Figure D16. Flowchart for PREVENT.

RIGID

Purpose

Subroutine RIGID calculates and sums M&R costs for rigid pavements.

Formal Parameters

The header card for RIGID is:

SUBROUTINE RIGID(XREPAIR,XSLJNT,XRESLAB,XCLEAN,XDISTOT,XTOTAL,KK, TRKK,ISTART,IEND,TMO).

Description

This subroutine computes the costs of maintenance activities at appropriate times for M&R of rigid pavements according to the formulae given in Chapter 2. These costs are also discounted to a present worth and totaled in this subroutine.

Variables

Variable	Location	Usage
AREA		Maintenance area considered (sq yd).
CLEAN		Cost factor for CLEANING.SWEEPING.RIGIDPAVEMENT.
CLNDRN	/PRVNT/	Cost/sq yd for MAINTAIN.DRAINS.
CLNSWP	/PRVNT/	NA
COSTF	/PRVNT/	NA
COSTR	/PRVNT/	Cost/sq yd for OTHER.MAINTENANCE.RIGIDPAVEMENT.
CRSL	/PRVNT/	NA
DISTOT		Total cost per year with DISCOUNT and ESCALATION.RATE included.
DRAINS		Cost factor for MAINTENANCE.DRAINS.
FACTR1	/PRVNT/	Cost/sq yd for SEALING.JOINTS.CRACKS. RIGIDPAVEMENT.

Variable	Location	Usage
FACTR2	/PRVNT/	Cost/sq yd for CLEANING.SWEEPING. RIGIDPAVEMENT.
FACTR3	/PRVNT/	Cost/sq yd for REPLACE.SLABS.RIGIDPAVEMENT.
FRSTSL	/PRVNT/	NA
ICYCLE	/PRVNT/	Cyclic period for sealing joints and cracks.
IEND	FP	Counter for end year of overlay.
IFL	/PRVNT/	NA
INDXRF(35)	/NDXRF/	Array containing overlay type for the years of overlays: 1 - rigid 2 - flexible 3 - no overlay this year.
IRG	/PRVNT/	Number of cost pairs for OTHER.REPAIRS. RIGIDPAVEMENT.
ISTART	FP	First year of overlay.
ISTRT		First year of overlay.
JCYCLE	/PRVNT/	Time interval between occurrences of MAINTAIN.DRAINS.
JDL	/SCAN3/	Design life of pavement in years.
KK	FP	Number of overlays.
KREP		Year for OTHER.REPAIRS.RIGIDPAVEMENT.
KS		Counter for OTHER.REPAIRS.RIGIDPAVEMENT.
NA		T.V. for the number of years since overlay placement.
NB		Difference in years between overlays.
NC		Index indicating number of years since placement of overlay.

Variable	Location	Usage
NFL	/PRVNT/	NA
NRG	/PRVNT/	Interval in years between the activity OTHER.MAINTENANCE.RIGIDPAVEMENT.
PERCENT(25)		Percentage of slab area to be replaced in the Ith year.
PTCH	/PRVNT/	NA
REPAIR		Cost factor for REPAIR.SCALING.POPOUTS. RIGIDPAVEMENT.
REPFL(10,2)	/PRVNT/	Array for OTHER.REPAIRS.FLEXIBLE.PAVEMENT: REPFL(I,1) is the year REPFL(I,2) is the cost for that year.
REPRG(10,2)	/PRVNT/	Array for OTHER.REPAIRS.RIGIDPAVEMENT: REPRG(I,1) is the year REPRG(I,2) is the cost for that year.
RESLAB		Cost factor for REPLACE.SLABS.RIGIDPAVEMENT.
RIGMAN		Cost factor for OTHER.MAINTENANCE.RIGIDPAVEMENT.
RIGPAR		Cost for OTHER.REPAIRS.RIGIDPAVEMENT.
SCLPOP	/PRVNT/	Cost/sq yd for REPAIR.SCALING.POPOUTS. RIGIDPAVEMENT.
SLCT	/PRVNT/	NA
SLJNT		Cost factor for SEALING.JOINTS.CRACKS. RIGIDPAVEMENT.
TMO(10,4)	FP	Array containing overlay information: TMO(I,1): 1 = Ith overlay is rigid 2 = Ith overlay is flexible. TMO(I,2): overlay thickness, in inches. TMO(I,3): 2 = partially bonded rigid overlay 3 = unbonded rigid overlay. TMO(I,4): XK, the subgrade modulus, or AXK, effective modulus for rigid overlays over asphalt.

Variable	Location	Usage
TOTAL(35)	/TTL/	Sum of repairing scales and popouts, sealing joints and cracks, replacing slabs, and cleaning and sweeping costs.
TRKK	FP	Total thickness of pavement overlay since first rigid overlay on pavement.
TRST	/DMBLK/	Economic factor which combines DISCOUNT and ESCALATION.RATE.
XCLEAN	FP	Total cost for CLEANING.SWEEPING.RIGIDPAVEMENT.
XDISTOT	FP	Total cost with DISCOUNT and ESCALATION.RATE included.
XREPAIR	FP	Total cost for REPAIR.SCALING.POPOUTS. RIGIDPAVEMENT.
XRESLAB	FP	Total cost for REPLACE.SLABS.RIGIDPAVEMENT.
XSLJNT	FP	Total cost for SEALING.JOINTS.CRACKS. RIGIDPAVEMENT.
XTOTAL	FP	Total maintenance cost for rigid pavement analysis.

Common Blocks

The common blocks in RIGID are:

ARBK, DMBLK, NDXRF, PRVNT, SCAN3, TTL.

Tapes

None.

Traceback

Subroutine RIGID is called by PREVENT and calls the inline function INT.

Illustrations

Figure D17 is a flowchart of subroutine RIGID.

References

None.

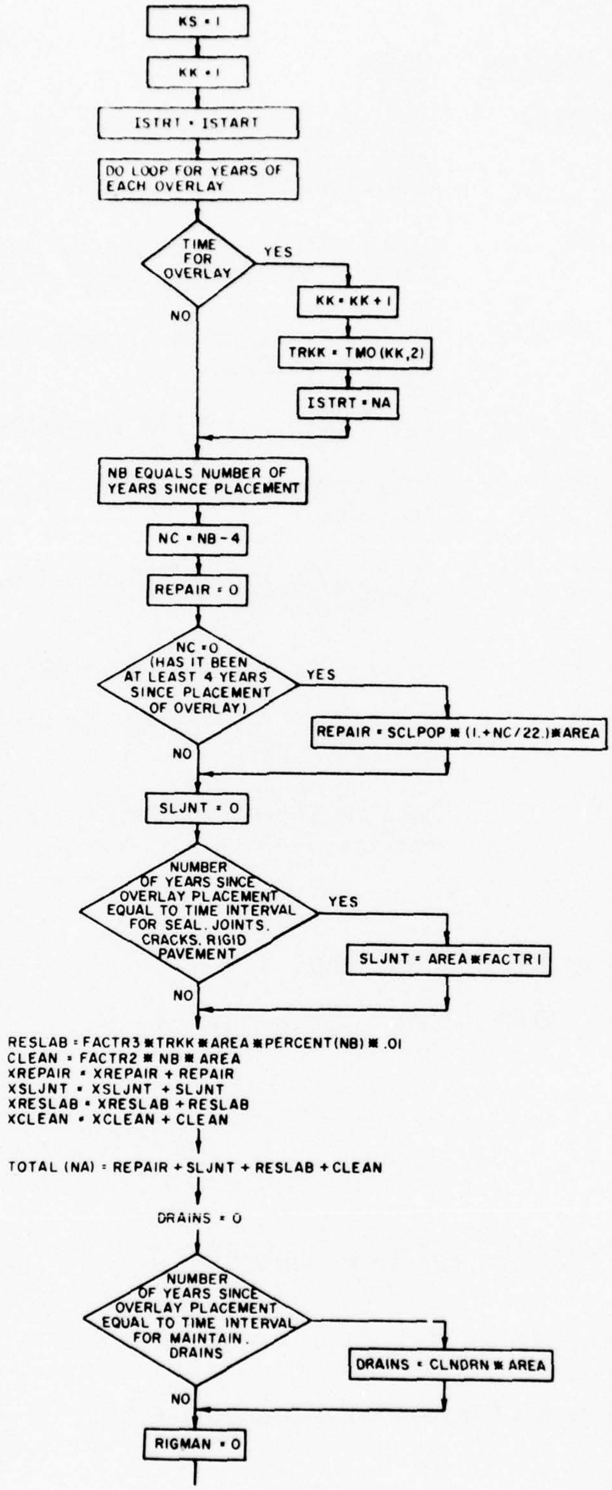

Figure D17. RIGID flowchart.

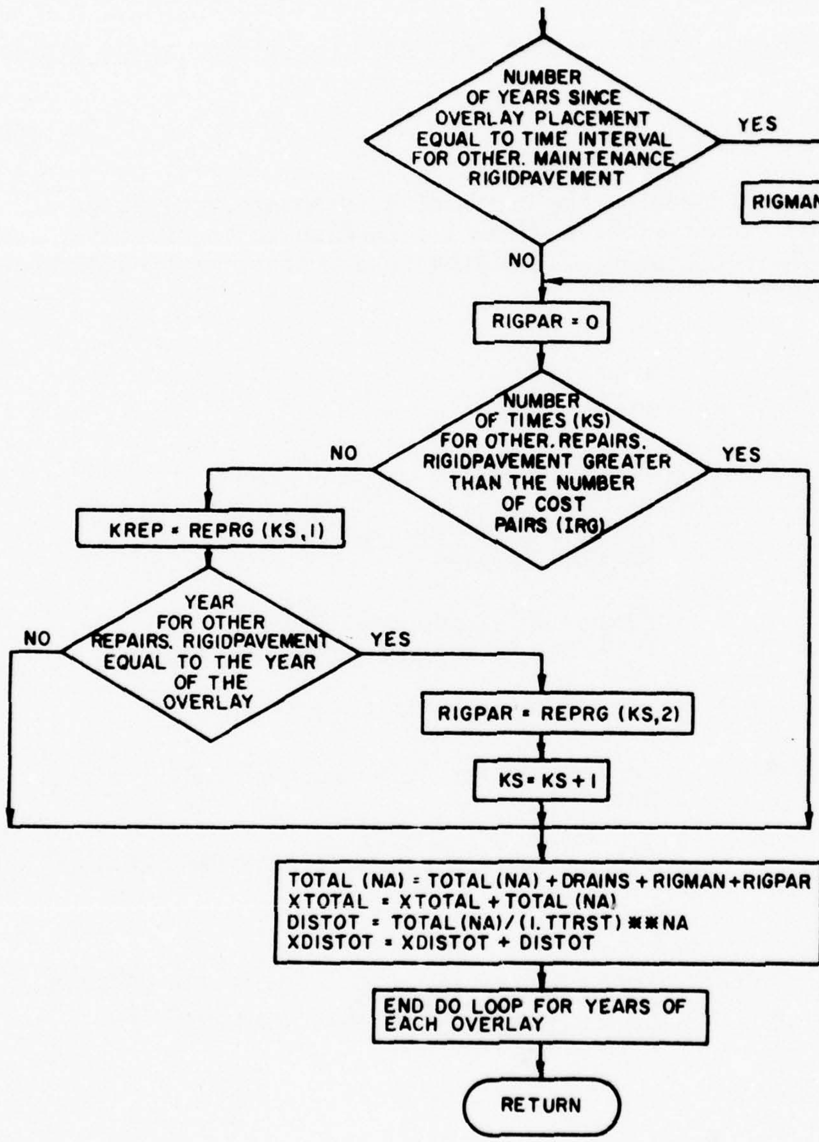

Figure D17 (cont'd).

FLEXBL

Purpose

Subroutine FLEXBL calculates and sums M&R costs for flexible pavements.

Formal Parameters

The header card for FLEXBL is:

SUBROUTINE FLEXBL(TTSLCT,TTCRPT,TCLNDRN,TCLNSWP,TTOT,TDTOT,ISTART, IEND).

Description

This subroutine computes the costs of maintenance activities at appropriate times for flexible pavements according to the formulae given in Chapter 2. These costs are discounted to a present worth and totaled in this subroutine.

Variables

Variable	Location	Usage
AREA	/ARBK/	Area (sq yd).
CCLNDRN(35)		Array containing cost factors for MAINTAIN.DRAINS.
CCLNSWP(35)		Array containing cost factors for CLEANING.SWEEPING.FLEXIBLE.PAVEMENT.
CLNDRN	/PRVNT/	Cost/sq yd for MAINTAIN.DRAINS.
CLNSWP	/PRVNT/	Cost/sq yd for CLEANING.SWEEPING.FLEXIBLE. PAVEMENT.
COSTF		Cost/sq yd for OTHER.MAINTENANCE.FLEXIBLE.PAVEMENT.
COSTR		NA
CRKPTCH(35)		Array containing cost factors for PATCHING. FLEXIBLE.PAVEMENT and/or CRACKSEALING. FLEXIBLE.PAVEMENT.

Variable	Location	Usage
CRSL	/PRVNT/	Cost/sq yd for CRACKSEALING.FLEXIBLE. PAVEMENT.
DTOT		Discounted maintenance cost for one year.
FACTR1	/PRVNT/	NA
FACTR2	/PRVNT/	NA
FACTR3	/PRVNT/	NA
FLXMAN		Cost for other MAINTENANCE.FLEXIBLE.PAVEMENT.
FLXPAR		Cost for a particular year for OTHER.REPAIRS. FLEXIBLE.PAVEMENT.
FRSTSL	/PRVNT/	NA
I		T.V.
ICOUNT	/RESTR/	NA
ICYCLE	/PRVNT/	NA
IDQ	/DOBK/	NA
IEND	FP	Counter for end year of the overlay.
IFL	/PRVNT/	Number of cost pairs for OTHER.REPAIRS. FLEXIBLE.PAVEMENT.
IJ		Counter for number of seal coats required.
INDXRF(35)	/NDXRF/	Array containing overlay type at end year of overlay: 1 = rigid 2 = flexible 3 = no overlay this year.
IREST	/RESTR/	Index for DESIGN.RESTRICTION: 1 = none 2 = rigid 3 = flexible.
IRG	/PRVNT/	NA

Variable	Location	Usage
ISTART	FP	First year of overlay.
ISTRT		First year of overlay.
ITY		Index for design type (DTYPE): 1 = rigid 2 = flexible.
IYR		Initial year of flexible pavement.
JCYCLE		Time interval between occurrences of MAINTAIN.DRAINS.
JDL	/SCAN3/	Design life of pavement in years.
JREST	/RESTR/	NA
JS		Counter for OTHER.REPAIRS.FLEXIBLE.PAVEMENT.
JYR		Number of years without sealcoating (with rigid pavement, seal coating is not an option until next flexible pavement; thus JYR = 100).
L		Number of years since overlay placement.
NFL	/PRVNT/	Time interval between occurrences of OTHER.MAINTENANCE.FLEXIBLE.PAVEMENT.
NRG	/PRVNT/	NA
PATCH		Total cost for PATCHING.FLEXIBLE.PAVEMENT.
PTCH	/PRVNT/	Cost/sq yd for PATCHING.FLEXIBLE.PAVEMENT.
REPFL(10,2)	/PRVNT/	Array for OTHER.REPAIRS.FLEXIBLE.PAVEMENT: REPFL(I,1) is the year REPFL(I,2) is the cost for that year.
REPRG(10,2)	/PRVNT/	NA
SCLPOP	/PRVNT/	NA
SEALYR(15)		Array containing years in which sealcoating is required.

Variable	Location	Usage
SLCOAT(35)		Array containing cost factor for SURFACE. TREATMENT.FLEXIBLE.PAVEMENT.
SLCT	/PRVNT/	Cost/sq yd for SURFACE.TREATMENT.FLEXIBLE. PAVEMENT.
TCLNDRN	FP	Total cost for MAINTAIN.DRAINS.
TCLNSWP	FP	Total cost for CLEANING.SWEEPING.FLEXIBLE. PAVEMENT.
TDTOT	FP	Total discounted maintenance cost for flexible.
TOT		Total cost for a given year without DISCOUNT and ESCALATION.RATE.
TOTAL(35)	/TTL/	Array containing total cost per year without DISCOUNT and ESCALATION.RATE.
TRST	/DMBLK/	Economic factor which combines DISCOUNT and ESCALATION.RATE.
TTCRPT	FP	Total cost for CRACKSEALING.FLEXIBLE.PAVEMENT.
TTOT	FP	Total maintenance cost for flexible.
TTSLCT	FP	Total cost for SURFACE.TREATMENT.FLEXIBLE. PAVEMENT.

Common Blocks

The common blocks in FLEXBL are:

ARBK, DMBLK, DOBK, NDXRF, PRVNT, RESTR, SCAN3, TTL.

Tapes

Subroutine FLEXBL is called by PREVENT and calls the inline function INT.

Illustrations

Figure D18 is a flowchart of FLEXBL.

References

None.

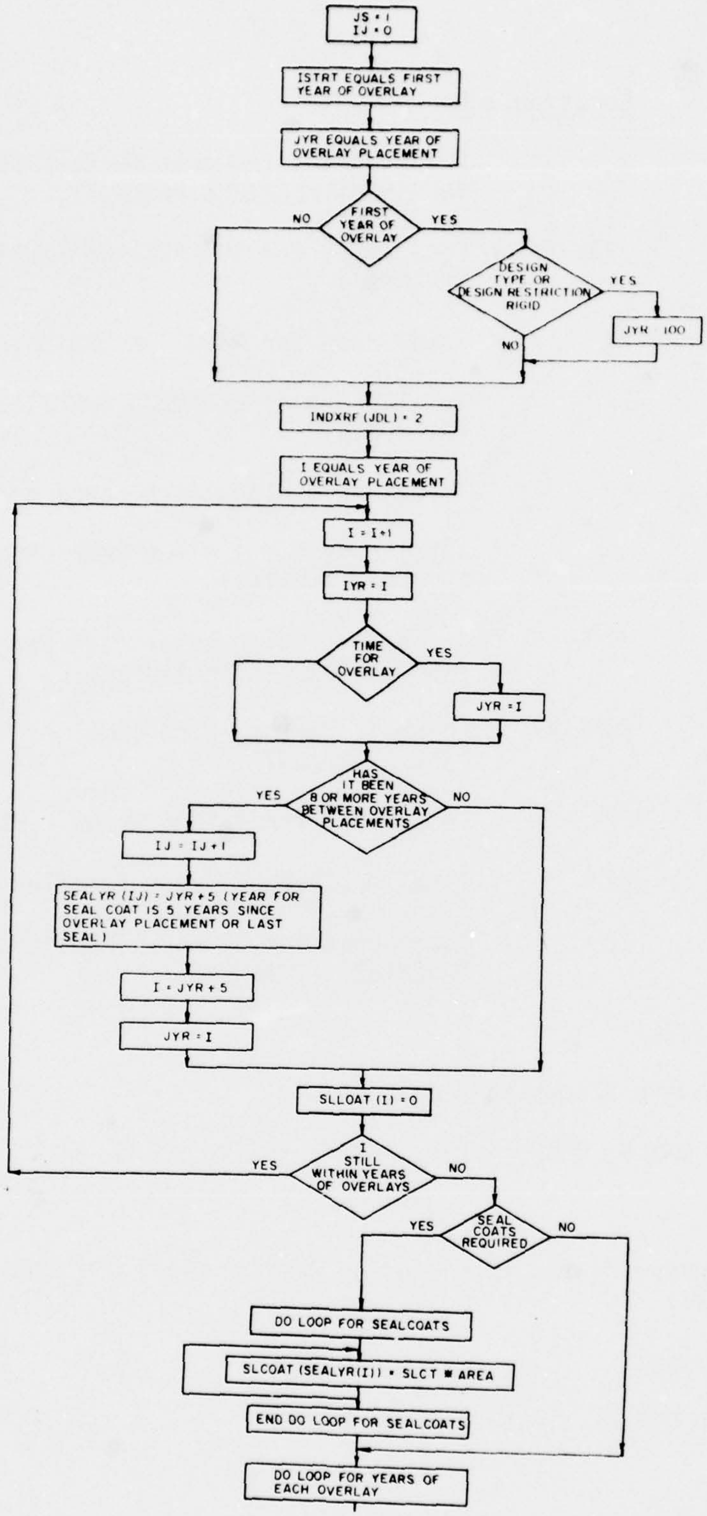

Figure D18. FLEXBL flowchart.

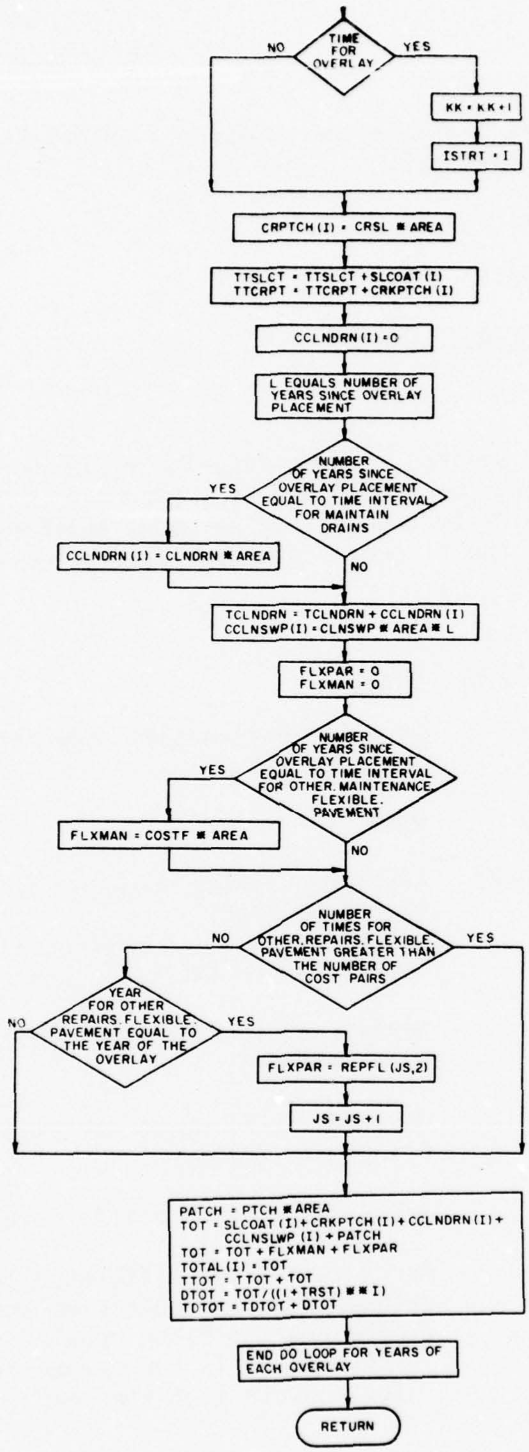

Figure D18 (cont'd).

RDO

Purpose

RDO defines traffic data and produces a thickness versus time curve for rigid pavement overlays.

Formal Parameters

The header card for RDO is:

SUBROUTINE RDO(TN,TL,OTH).

Description

Subroutine RDO defines traffic data for rigid pavement overlay design. It considers the effect of wheel type and uses subroutines GINT, MIXED and RODTHK to produce the pavement thickness versus time curve starting from the time of rigid overlay placement.

Variables

Variable	Location	Usage
AHH(10)	/HBLK/	Array of thicknesses used for rigid pavement over asphalt.
AXK	/LCY/	NA
COVRGD(10,20)	/MIXBLK/	Array containing vehicle coverages at the year specified: COVRGD(I,J) is number of coverages at the year in TM(J) for vehicle I.
CV(20)		Array containing vehicle coverages at the year in TM(I).
CVV		Coverage level up to the time of the overlay being considered.
DUM(20)		Array containing traffic coverages.
DUMBGD(10,20)		Array containing difference in coverage levels between the year specified and the time of the overlay being considered: DUMBGD(I,J) is the number of coverages for vehicle I at the year in TM(J).

Variable	Location	Usage
FACQ	/LCY/	NA
FAIL2(10,10)	/EMBLK/	Array containing coverages to failure. FAIL2(I,J) is number of coverages for thickness AHH(I) and vehicle J.
HH(10)	/HBLK/	NA
I		T.V.
IAA(10)	/LTTBLK/	Array containing the wheel type index for each vehicle: 02 - twin tandem 00 - all others.
IDF	/RODLOD/	NA
IDR	/RODLOD/	NA
IMIX	/MIXBLK/	Number of vehicles.
J		T.V.
K		T.V.
KK		Number of members in an array.
L		T.V.
LS	/LCY/	Number of years at which thickness calculations are performed.
LTT(10)	/LTTBLK/	NA
LZ	/RODLOD/	Indicates road design when equal to 3.
NODQ	/NBLK/	NA
NOGQ	/NBLK/	NA
NOH	/NBLK/	Number of thicknesses in AHH array.
NOSGQ	/NBLKL/	NA
NPTQ	/NBLK/	NA

Variable	Location	Usage
NXQ	/NBLK/	NA
NYQ	/NBLK/	NA
OTH	FP	Overlay thickness (inches).
STOR1Q(10,10)	/MIXBLK/	NA
STOR2Q(10,10)	/MIXBLK/	NA
TL	FP	Time to end of last overlay design or time to beginning of overlay being considered.
TM(20)	/HBLK/	Array containing the years at which the program calculates pavement thicknesses (not to be confused with TIMES.OF.OVERLAY).
TN	FP	Time to end of overlay being considered.
TRA(20)	/BMBLK/	Array containing required thickness (inches) at the years specified in the TM array.
TRAA(20)	/BMBLK/	Array containing required thickness (inches) at the years specified in TM array, rounded on the 1/4 in (6.35 mm).
TRYQ(20)	/LCY/	NA
XK	/NBLK/	NA
YKQ	/LCY/	NA

Common Blocks

Common blocks in RDO are:

BMBLK, EMBLK, HBLK, LCY, LTTBLK, MIXBLK, NBLK, RODLOD.

Tapes

The tape used by RDO is:

TAPE6 -- writes information to the debug file.

Traceback

Subroutine RDO is called by OVTHK and calls SQRT (CDC Library), GINT, MIXED RODTHK, and the inline function AINT.

Illustrations

A flowchart of RDO is presented in Figure D19.

References

None.

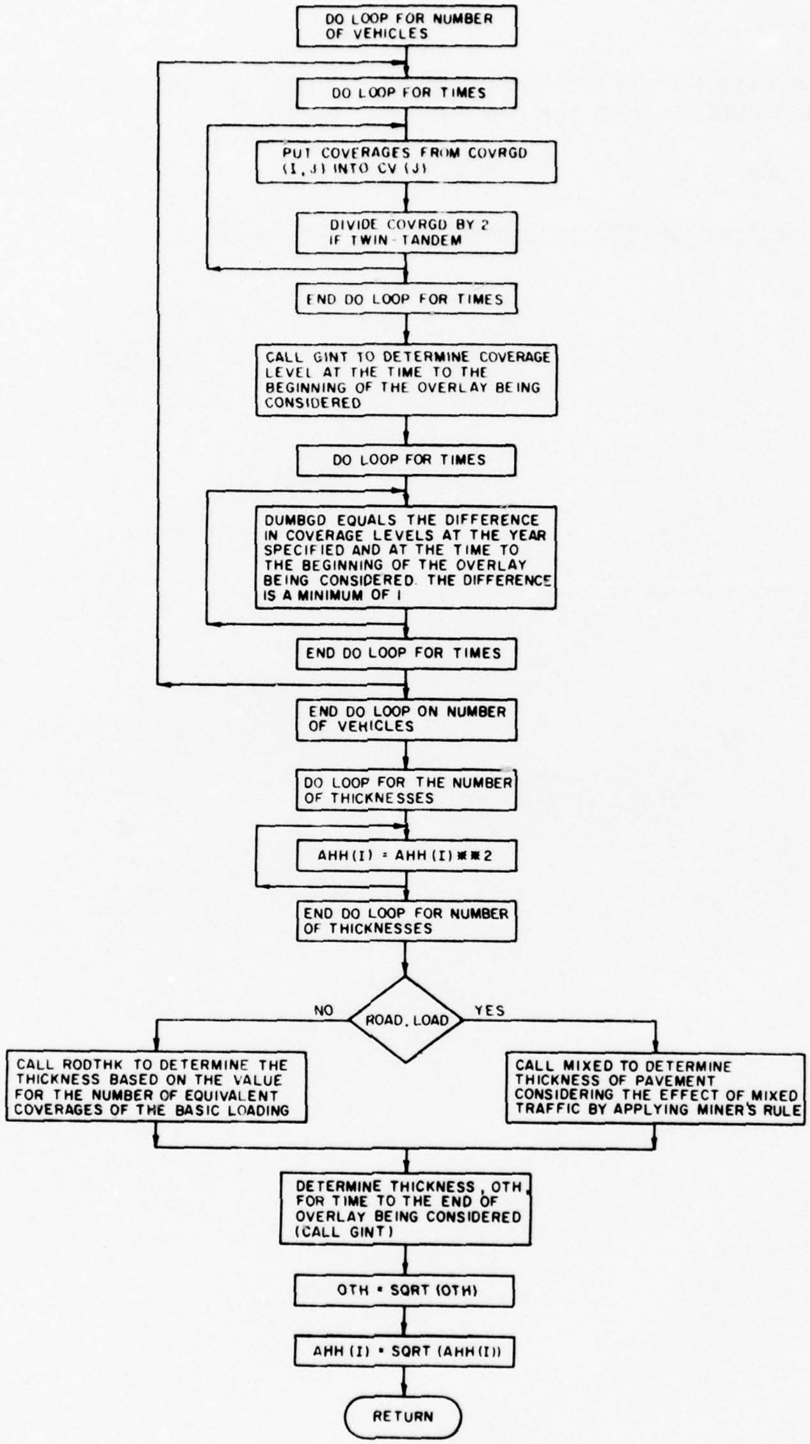

Figure D19. RDO flowchart.

MOAC

Purpose

MOAC determines the total discounted maintenance and overlay cost for a particular overlay strategy, including the routine maintenance and/or maintenance cost analysis.

Formal Parameters

The header card for MOAC is:

SUBROUTINE MOAC(TMO,STRT,NSTRT,COM).

Description

MOAC calculates ROUTINE.MAINTENANCE and overlay costs for each year in the pavement design life. These costs are discounted to present worth. Subroutine PREVENT is called by MOAC to calculate itemized maintenance costs if MAINTENANCE.COST.ANALYSIS is included. These costs are included in the total cost of the maintenance strategy produced in MOAC.

Figure D20 is a flowchart of MOAC.

Variables

Variable	Location	Usage
AREA		Area (sq yd).
AXKQ	/LCY/	NA
BASET		Base thickness (inches) for roadway flexible pavement.
CBR		California Bearing Ratio.
COM	FP	Discounted cost of maintenance strategy.
CR		Routine maintenance cost.
CTOT		Total discounted maintenance cost for one year.
CTOV		Total overlay cost; final value is total overlay cost plus total base course cost where applicable.
CTOV1		Total base course cost.

Variable	Location	Usage
DTOTAL		Total discounted maintenance cost from PREVENT.
EARTHWK	/RL1/	NA
FACQ	/LCY/	NA
FACTOR	/RL1/	Geographical factor.
HHQ(10)	/HBLK/	NA
I		T.V.
IB		Variable for TMO(I3): 2 - partial bond rigid overlay 3 - unbonded rigid overlay.
IBASE		Index designating CBR of base: 1 - 100 CBR 2 - 80 CBR.
ICONT	/COUNT/	Counter for trial number.
IDENT(3)	/RL1/	NA
IDF	/RODLOD/	Design index for flexible pavement for roads (1-10).
IDQ	/DOBK/	NA
IDR	/RODLOD/	Design index for rigid pavement for roads (1-10).
IPBQ		Index indicating pavement material, used by TLMM.
ISB		Index designating 80 CBR of layer beneath base; used by TLMM.
ISKIP	/PRVNT1/	NA
ITDR		Design life of pavement in years.

Variable	Location	Usage
ITY	/DOBK/	Index designating design type (DTYPE): 1 - rigid 2 - flexible.
ITYP		Index designating design type (DTYPE). 1 - rigid 2 - flexible.
J		Counter for layer number.
JDL	/SCAN3/	Design life of pavement in years.
JISKIP	/PRVNT1/	Indicates ROUTINE.MAINTENANCE is to be calculated when equal to 1.
JTYPE		Index indicating current surface layer: 1 = rigid 2 = flexible.
K		Counter for years.
KKEEP		Counter for years.
K4	/RL1/	NA
L		Number of years for overlay.
LFUNC	/TYPBK/	Index for TRAFFIC.AREA (airfields) or CLASS.OF.ROAD: 1 = A 4 = D 2 = B 5 = E 3 = C 6 = F.
LJ		Variable for layer number.
LK		Variable for layer number.
LL		T.V. for TMO(I,1): 1 = rigid 2 = flexible. Used for ROUTINE.MAINTENANCE cost index.

Variable	Location	Usage
LMH	/TYPBK/	Index for load category: 1 = light load 2 = medium load 3 = heavy load.
LS	/LCY/	NA
LZ	/RODLOD/	Indicates road design when equal to 3.
M		Counter for the number of layers.
MM		Variable for trial number; used by PREVENT.
MMM		Reference number for base course cost item; used by SERCST.
NB	/LYTD/	Number of base layers.
NCOM	/LYTD/	Number of compacted layers.
NNAT	/LYTD/	NA
NNN		Reference number for cost items.
NSBB	/LYTD/	Number of subbase layers.
NSTRT	FP	Number of overlays in a particular strategy.
SIC		Cost/sq yd/in. for base thickness TKH.
STRT(10)	FP	Years of each overlay placement in a strategy.
SYC		Cost/sq yd/in. for layer thickness THK.
THK		Layer thickness (inches).
TKH		Base thickness (inches).
TLIM		Minimum thickness (inches) of flexible pavement.
TLM		Thickness (inches).
TM(20)	/HBLK/	NA

Variable	Location	Usage
TMO(10,4)	FP	Array containing overlay information TMO(I,1): 1 = Ith overlay is rigid 2 = Ith overlay is flexible. TMO(I,2): overlay thickness in inches. TMO(I,3): 2 = partially bonded rigid overlay 3 = unbonded rigid overlay. TMO(I,4): XK, the subgrade modulus, or AXK, effective modulus for rigid overlays over asphalt.
TN		Years; used by SERCST.
TRST	/DMBLK/	Economic factor which combines DISCOUNT and ESCALATION.RATE.
TRYQ(20)	/LCY/	NA
TUU		Minimum thickness of pavement plus base (inches).
XMT(10,6)	/LYTD/	NA
YCBR(10,4)	/LYTD/	NA
YKQ	/LCY/	NA
ZCBR(10,6)	/LYTD/	NA
ZMT(3,4)		Array containing CBRs of the base layers: ZMT(I,1)--CBR of layer I.

Common Blocks

The common blocks used in MOAC are:

ARBK, COUNT, DMBLK, DOBK, HBLK, LCY, LYTD, PRVNT1, RL1, RODLOD, SCAN3, TYPBK.

Tapes

The tape used in MOAC is:

TAPE6 -- writes messages to debug file.

Traceback

Subroutine MOAC is called by CONSEQ and calls PREVENT, MTHICK, TLMM, SERCST, and the inline functions FLOAT and INT.

Illustrations

The MOAC flowchart is presented in Figure D20.

References

None.

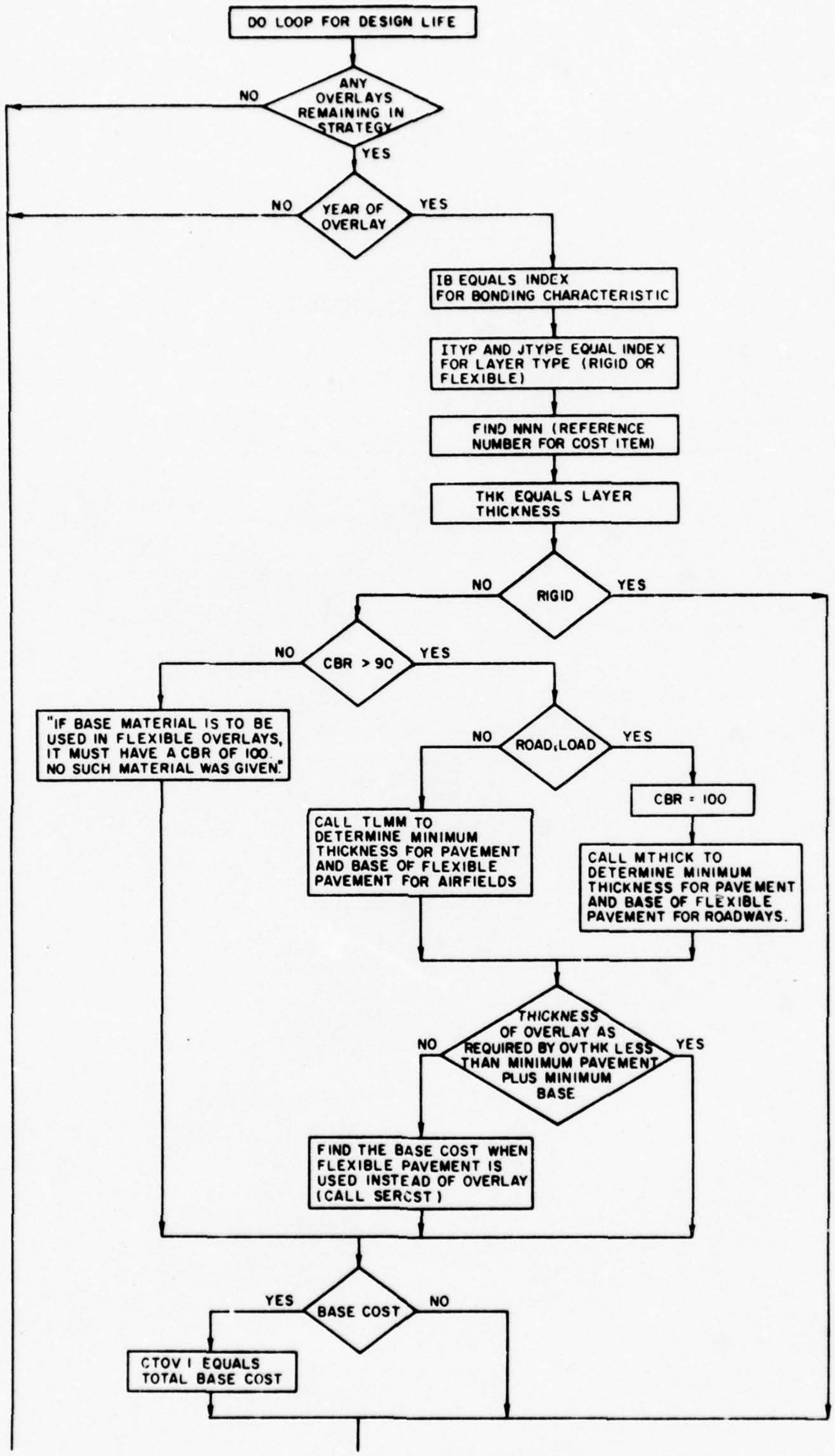

Figure D20. MOAC flowchart.

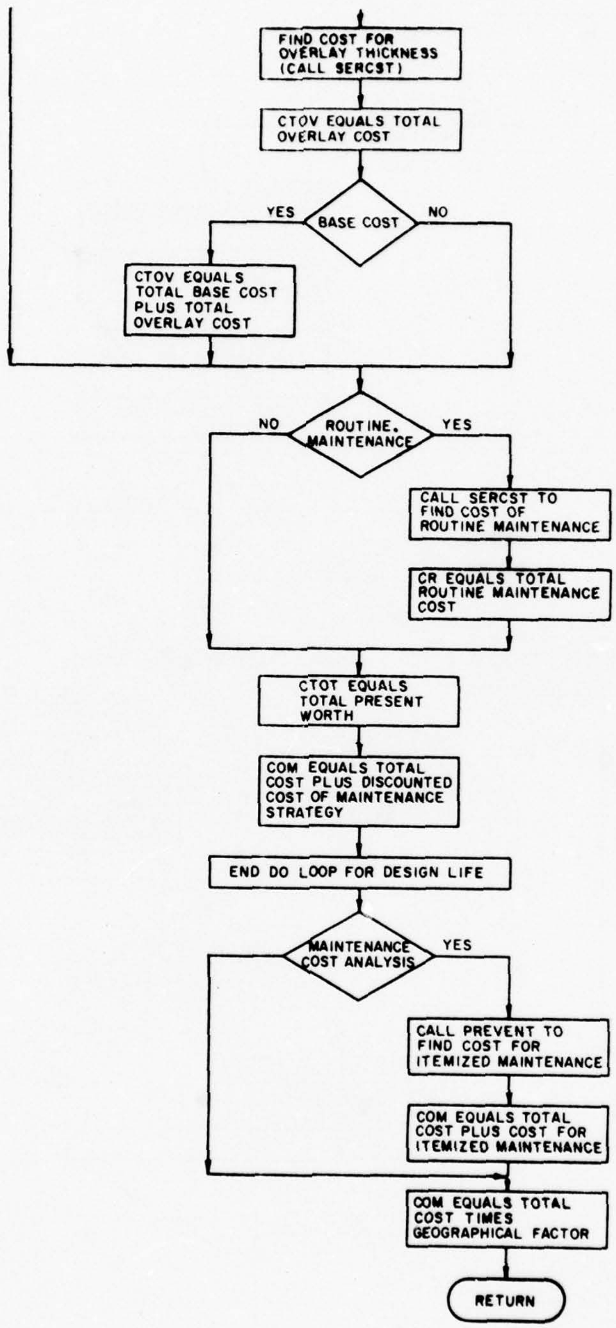

Figure D20 (cont'd).

USRC

Purpose

USRC calculates user costs for VEHICLE.MAINTENANCE.

Formal Parameters

The header card for USRC is:

SUBROUTINE USRC(TMO,STRT,NSTRT,CTU).

Description

Estimates of anticipated vehicle maintenance costs caused by pavement roughness, slipperiness, or structural failures are input as time (years) vs. cost ($) curves. Nine pairs of time-cost data can be used to define the curve. The maximum time used must be greater than the maximum service life of the facility. Time for VEHICLE.MAINTENANCE is reset at zero after completion of each structural overlay or reconstruction activity.

Variables

Variable	Location	Usage
CAM		T.V.
CCCST(50,10,2)	/CSTBK/	Cost array where: CCCST (I,1,1) is the number of curve segments for variable I; CCCST (I,J,1) is the value on the abscissa for the (J-1) cost data pair; CCCST (IJ2) is the value on the ordinate for the (J-1) cost data pair (i.e., the cost).
CTOT		Total discounted cost/year of delay and vehicle maintenance.
CTU	FP	Accumulated cost over design life.
DLC		A lump sum ($) reflecting the cost of closing the facility during construction of an overlay.

Variable	Location	Usage
DLCF	/CUSR/	A lump sum ($) reflecting the cost of closing the facility during construction of a flexible overlay.
DLCR	/CUSR/	A lump sum ($) reflecting the cost of closing the facility during construction of a rigid overlay.
I		T.V.
ITDR		JDL (design life of pavement in years).
ITYP		Type of overlay: 1 = rigid 2 = flexible.
J		Index counter for overlays.
JDL	/SCAN3/	Value for DESIGN.LIFE.
K		Counter for years.
KKEEP		Counter for years.
L		Year of next overlay placement.
M		Counter for overlays.
MM		Number of cost curve segments.
NB	/LYTD/	Number of base layers.
NCOM	/LYTD/	Number of compacted layers.
NNAT	/LYTD/	NA
NNN		VEHICLE.MAINTENANCE index for CCCST array.
NSBB	/LYTD/	Number of subbase layers.
NSTRT	FP	Number of overlays in a particular strategy.
STRT(10)	FP	Array containing years of overlays.
SYC		Cost of VEHICLE.MAINTENANCE.

Variable	Location	Usage
TMO(10,4)	FP	Array containing overlay information: TMO(I,1): 1 = Ith overlay is rigid 2 = Ith overlay is flexible. TMO(I,2): overlay thickness in inches. TMO(I,3): 2 = partially bonded rigid overlay 3 = unbonded rigid overlay. TMO(I,4): XK, the subgrade modulus, or AXK, effective modulus for rigid overlays over asphalt.
TN		Time (years) of cost item for which cost is to be calculated.
TRST	/DMBLK/	Economic factor which combines DISCOUNT and ESCALATION.RATE.
XMT(10,6)	/LYTD/	NA
YCBR(10,4)	/LYTD/	NA
ZCBR(10,6)	/LYTD/	NA

Common Blocks

The common blocks in USRC are:

CSTBK, CUSR, DMBLK, LCY, SCAN3.

Tapes

None.

Traceback

Subroutine USRC is called by CONSEQ and calls SERCST and the inline function FLOAT and INT.

Illustrations

Figure D21 is a descriptive flowchart of USRC.

References

None.

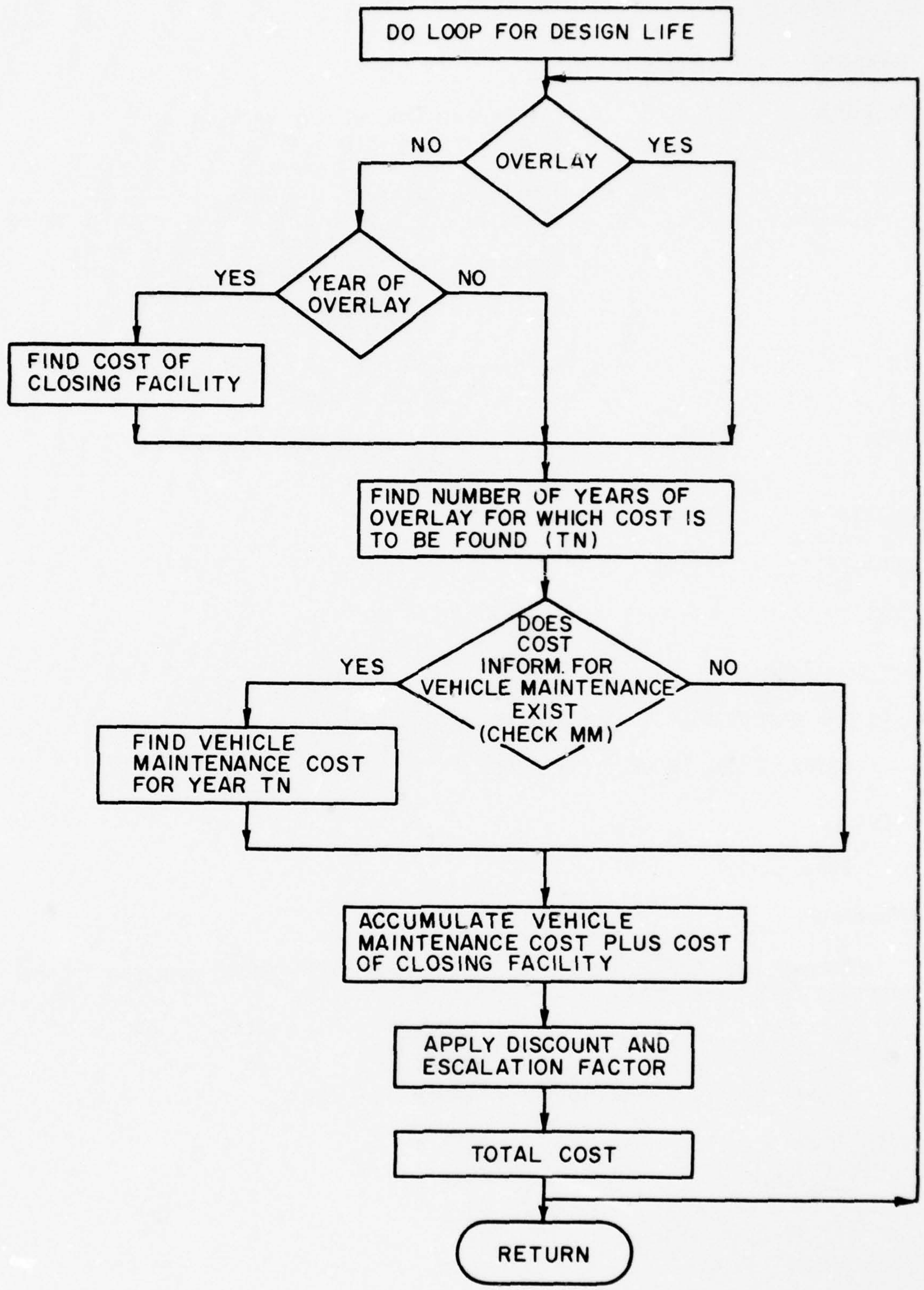

Figure D21. USRC flowchart.

MIXED

Purpose

This routine produces the required pavement thicknesses, using Miner's Rule to account for mixed traffic.

Formal Parameters

The header card for MIXED appears as follows:

SUBROUTINE MIXED(C,F,N,H,T,D,IM,LS).

Description

MIXED considers mixed traffic by applying Miner's rule. It selects a thickness of pavement such that

$$\sum_{i=1}^{m} \frac{\text{coverages of vehicle } i}{\text{coverages to failure for vehicle } i \text{ at a given thickness}} = 1$$

Thicknesses are found at years specified by the TIMES input variable. Note that if the required thickness for rigid design exceeds the upper parameter of RANGE.OF.THICKNESS, a message is written to the user, and the program is stopped.

Variables

Variable	Location	Usage
AP		Computed thickness for a given Miner's rule value (assigned value of 1.0 for flexible design when coverages are less than coverages to failure).
C(10,LS)	FP	Array containing coverage levels for each vehicle.
D(20)	FP	Array containing required pavement thicknesses at the years specified by the TIMES input variable.
F(10,N)	FP	Array containing coverages to failure for each vehicle at each thickness indexed by N.

Variable	Location	Usage
H(N)	FP	Array containing thicknesses of pavement (squared) at which coverages to failure are calculated.
I		T.V.
IM	FP	Number of vehicle types.
IRN		Counter for number of Miner's rule values which equal zero (i.e., no coverages for that vehicle that year).
IT		Number of possible combinations of pavement thickness vehicle type.
J		T.V.
K		T.V.
KK		Array dimension.
KOUNT		Index counter for errors.
LK		T.V.
LS	FP	Number of years at which calculations are performed.
N	FP	Number of thicknesses: Rigid = 10 Flexible = 20.
RN		T.V.
T(20)	FP	Array containing required pavement thicknesses (inches) at the years specified by the TIMES input variable, rounded at the 1/4 in. (6.3 mm) and squared.
X		Log of 1 (0.0).
XMRN(20)		Log of Miner's rule number.
YMRN(10)		Log of Miner's rule number.

Common Blocks

None.

Tapes

Tapes used by MIXED are:

TAPE6 -- writes values for percent reliability and thickness to the debug file.

TAPE8 -- writes error message "MIXED -- THICKNESSES ARE IN ERROR, MUST BE LARGER" to the user.

Traceback

Subroutine MIXED is called by PAVE and RDO. It calls GINT, ALOG10 (CDC Library) and SQRT (CDC Library), and the inline function AINT.

Illustration

Figure D22 is a flowchart of MIXED.

References

None.

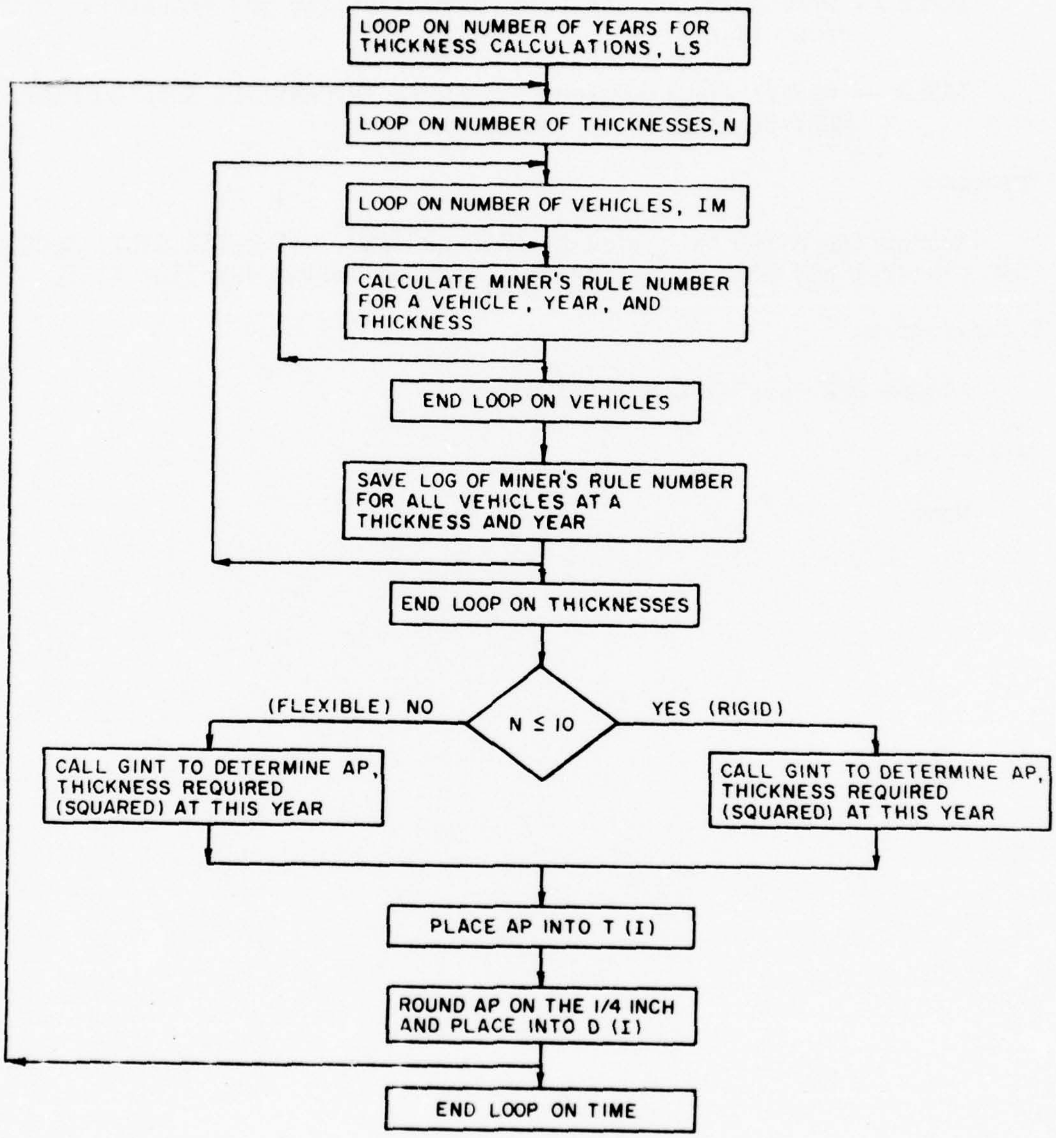

Figure D22. MIXED flowchart.

BTCT

Purpose

BTCT performs base tradeoff computations for rigid pavement design.

Formal Parameters

The header card for BTCT is:

SUBROUTINE BTCT(TT).

Description

BTCT performs base tradeoff computations, that is, the cost tradeoff produced by reducing the rigid pavement slab thickness because of increased base course thickness. A composite modulus, k_{eff}, is determined from the existing subgrade modulus of reaction for each of a standard set of base thicknesses. The required slab thickness above each base thickness is then computed. A cost estimate for each combination is generated, taking into account cost of pavement, base, drainage, and earthwork. BTCT saves and returns the combination of slab and base thicknesses providing the least cost.

Variables

Variable	Location	Usage
AKAY(7)		Array containing standard set of k values (k = 25, 50, 100, 200, 300, 400, 500).
AKEF(10)	/AKBLK/	Modified subgrade modulus k in pci. For BASE TRADEOFF, AKEF(I) is an effective k value for a base thickness I, where I is 10,20,30...100 (based on TM 5-888-9, Figure II-2). The lowest k value of AKEF(I) and AKEFT(I) is saved in AKEFT(I).
AKEFT(10)	/AKBLK3/	Modified subgrade modulus k in pci. For reduced subgrade strength analysis for rigid pavements in the frost analysis. AKEFT(I) contains a calculated k for thickness I, where I=10,20,30...100.
AKY	/AKBLK/	Subgrade modulus, k_{eff}.
AREA	/ARBK/	Section area, sq yd.

Variable	Location	Usage
AXK	/LCY/	NA
AXXK		Subgrade modulus, k_{eff}.
BASE		$/BSTK from SERCST.
BIG	/AKBLK/	Total cost of pavement and base, initialized to 10^7.
BSTK		Base thickness (inches).
BT(11)		Array containing the base thicknesses which correspond to k_{eff}.
CD		Log of coverages to failure for the dominant aircraft for the given design thickness, TT.
COV(10)		Array containing standard set of log of coverages.
COVRGD(10,20)	/MIXBLK/	Array containing vehicle coverage levels at the year specified; COVRGD(I,J) is number of coverages of vehicle I at time in TM(J) array.
CSTPAB		Total cost of base, pavement, earthwork, and damage/sq yd.
CUTPRCE	/TSV/	NA
CVD(20)		Log of coverages of the dominant aircraft for the year specified.
DRAIN	/DRNBLK/	Drainage cost.
DUM(10)		Array containing thicknesses, THICK (IJK), based on specific load category and k value.
EARTHWK	/RL1/	EARTHWORK code. If the code equals 1 or 2, the earthwork is to be included by a call to EXCOST3.
ERCOST	/TSV/	Cost for earthwork ($).
FAC	/LCY/	NA
FACTOR	/RL1/	NA

Variable	Location	Usage
FDE	/BSBLK/	Estimated depth of frost protection for FROST.DESIGN (inches).
FILPRCE	/TSV/	NA
I		T.V.
IBTE	/BSBLK/	Index for BASE.TRADEOFF and FROST.DESIGN:

	BASE.TRADEOFF	FROST.DESIGN
1	No	No or Read
2	unused	
3	Tradeoff	No
4	Tradeoff	Read
5	Tradeoff	Calculate
6	No	Calculate

Variable	Location	Usage
IDENT(3)	/RL1/	NA
IDF	/RODLOD/	NA
IDR	/RODLOD/	NA
IFLEXNA	/BLOCKD/	NA
IFSWIT(10)	/ABLK3/	Switch from PAVE; IFSWIT(1) equals: 0 - when reduced subgrade strength and IBTE equals 5 or 6 2 - when reduced subgrade strength and IBTE equals 5 3 - when complete or partial protection and IBTE equals 5.
INO		Index for standard set of coverages.
IRIGDNA	/BLOCKD/	Index for frost protection 1 - complete frost protection 2 or 6 - partial protection 6 - reduced subgrade strength.
J		T.V.
K		T.V.
KK		T.V.

Variable	Location	Usage
K4	/RL1/	NA
K7	/RL1/	NA
LMH	/TYPBK/	Index for LOAD.CATEGORY: 1 - light load 2 - medium load 3 - heavy load.
LS	/LCY/	Number of years specified at which thickness calculations are to be made.
LZ	/RODLOD/	Indicates road design when equal to 3.
MNT	/DOM/	Index for dominant aircraft (i.e., one which produces greatest stress at smallest thickness).
NODQ	/NBLK/	NA
NOGQ	/NBLK/	NA
NOHQ	/NBLK/	NA
NOSGQ	/NBLK/	NA
NPTQ	/NBLK/	NA
NUM(2)		NUM(I) contains the coverages for the given thickness, TT.
NXQ	/NBLK/	NA
NYQ	/NBLK/	NA
PAV		Cost/sq yd for pavement.
PAVT	/AKBLK/	Pavement thickness (rounded on the 1/4 in. [6.35 mm]).
PSTEP	/TSV/	NA
PVTFLX	/BLOCKD/	NA
PVTRGD	/BLOCKD/	NA

Variable	Location	Usage
RP		Thickness of pavement based on 5000 coverages of basic loading (from subroutine COV5K).
SAVT		Pavement thickness.
STORE(10)		Temporary storage array.
STORE1(10,10)		NA
STORE2(10,10)		NA
SVT		Pavement thickness (saved values).
T		Total thickness (pavement and base).
TBS	/AKBLK/	Base thickness (saved value).
TBT(11)		Array containing pavement thickness.
TC		Interpolated required thickness; based on coverages for specific load category and set of k values.
THCK	/TSV/	NA
THFF(20)	/THKBK/	NA
THICK(3,10,7)		Array containing thicknesses by load category, coverages, and k values (developed from TM 5-824-3).
THK(7)		Array of thicknesses at load category and specific coverage level.
TK		Thickness required above the subgrade at the year specified (from array TRKK).
TP		Thickness required above the subgrade at the year specified using K_{eff}.
TPAV		Pavement thickness (rounded on 1/4 in. [6.35 mm]).
TRKK(20)	/THKBK/	Array containing thickness required above the subgrade at the year specified.

Variable	Location	Usage
TRLL(1)		Percentage of thickness for 5000 coverages (from subroutine RODTHK).
TRPQZ(20)	/PQZ/	Array containing thickness required above the subgrade at the year specified; throughout the base tradeoff calculations, TRPQZ holds the TRKK array (thickness versus time).
TRY(20)	/LCY/	NA
TT	FP	Required pavement thickness for the current service life corresponding to the input subgrade modulus, k.
TTT		T.V. for thickness.
W		Index variable for TAPE number.
XCBR	/LCY/	NA
XK	/NBLK/	Subgrade modulus, k.
XSTR	/LCY/	Flexural strength, psi.
YK	/LCY/	NA
Z		T.V. used to retrieve one value from subroutine RODTHK.

Common Blocks

Common blocks in BTCT are:

ABLK3, AKBLK, ARBK, BLOCKD, BSBLK, DOM, DRNBLK, LCY, MIXBLK, NBLK, PQZ, RL1, RODLOD, THKBK, TSV, TYPBK.

Tapes

The tape used by BTCT is:

TAPE6 -- writes information to the debug file.

Traceback

Subroutine BTCT is called by PAVE and calls ALOG10 (CDC Library), COV5K, DRNAGE3, EXCOST3, GINT, RODTHK, and SERCST, and the inline functions AINT and FLOAT.

Illustrations

Figure D23 is a descriptive flowchart of BTCT.

References

Rigid Pavements for Airfields Other than Army, TM 5-824-3 (Department of the Army, December 1970).

Airfield Rigid Pavement Evaluation--Air Force Emergency Construction, TM 5-888-9 (Department of the Army, December 1966).

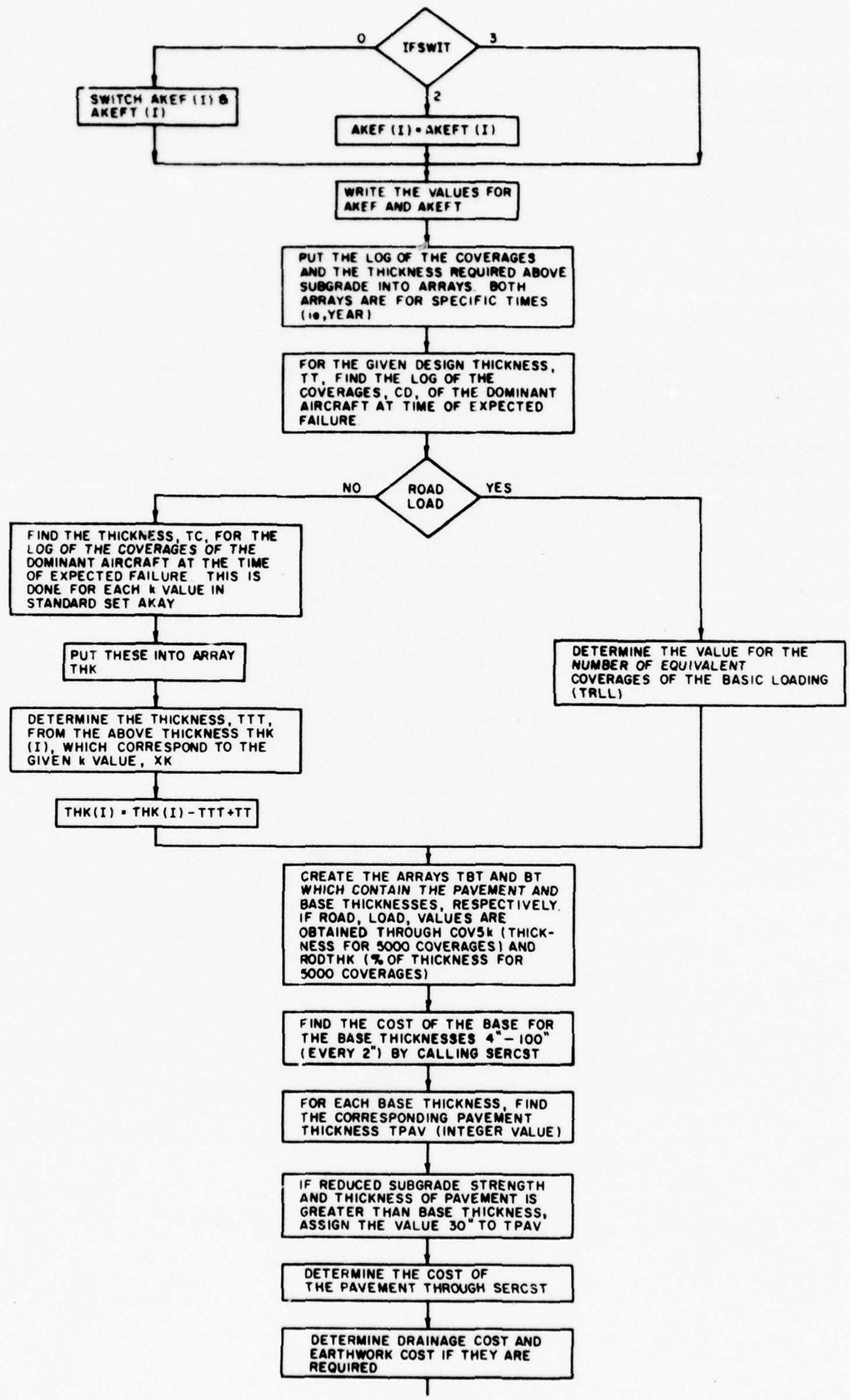

Figure D23. BTCT flowchart.

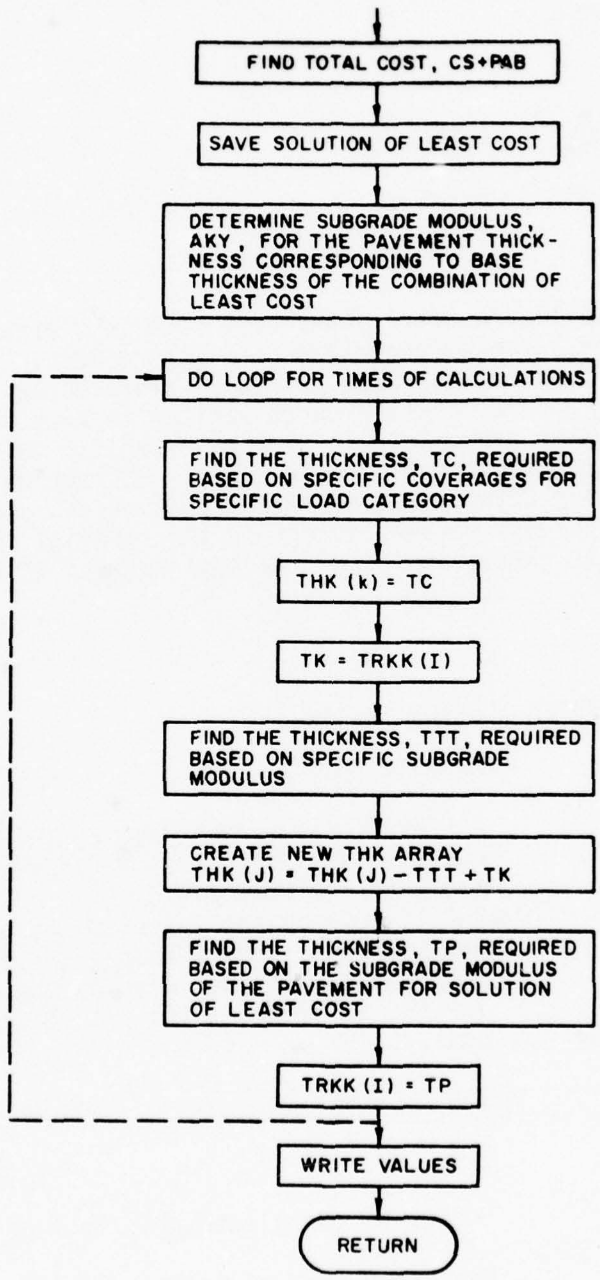

Figure D23 (cont'd).

SERCST

Purpose

The relative cost for a specific value of a cost parameter is determined by SERCST.

Formal Parameters

The header card for SERCST is:

SUBROUTINE SERCST(N,P,SYC).

Description

Subroutine SERCST transfers input cost data into arrays defining the cost curves for various parameters (see Figure D24). This provides the relationship of cost ($ or $/sq yd) to in-place material thickness (inches) for each material considered as well as to time of maintenance (years) for each maintenance activity. For a specific value of a cost parameter, SERCST returns the associated cost. Subroutine GINT is called to interpolate between values on the cost curve. Should the desired value of the cost parameters exceed the range of the input data, SERCST uses a linear extrapolation of the last segment of the cost curve to compute the cost.

Variables

Variable	Location	Usage
C(10)		CCCST(N,I,2)
CCCSST(50,10,2)		/CSTBK/ Cost array loaded by CTABLE, where: CCCST(I,1,1) is the number of curve segments for variable I; CCCST(I,J1) is the value on the abscissa for the (J-1) cost data pair; CCCST(I,J,2) is the value on the ordinate for the (J-1) cost data pair (i.e., the cost).
I		T.V.
J		T.V.
L		Number of coordinates of input cost data.
M		Maximum number of segments.

Variable	Location	Usage
N	FP	Reference number of cost item.
NUM		Number of segments plus 2 (used to check for nonexistent cost data).
P	FP	Specific value (inches or years) of cost item for which cost is to be calculated.
PAR(10)		CCCST(N,I,1).
SYC	FP	Output from SERCST, cost/P.

Common Blocks

The common block in SERCST is:

CSTBK.

Tapes

The tape used by SERCST is:

TAPE8 -- writes error message to user.

Traceback

Subroutine SERCST is called by PAVE, BTCT, USRC, MOAC, and LYR, and it calls GINT.

Illustrations

Figure D24 is a typical cost curve defined by program input. It provides the relationship of cost ($) to values of the cost item under consideration (e.g., inches of thickness for a material's construction cost).

References

None.

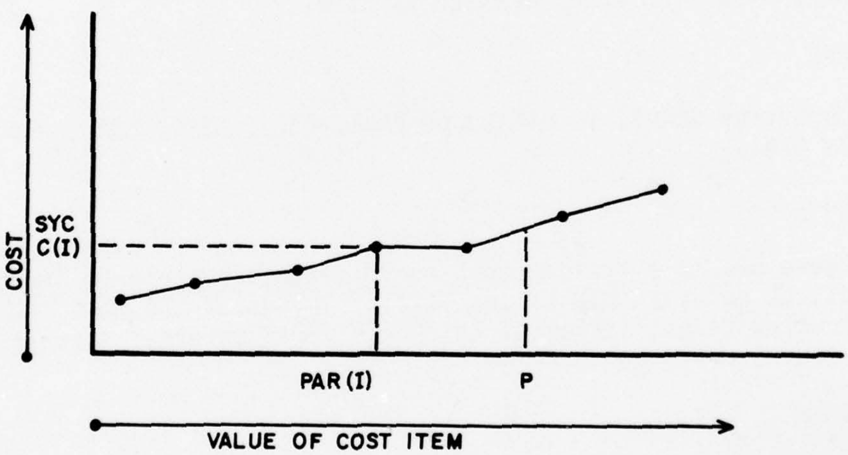

Figure D24. Typical cost curve.

APPENDIX E:

OVERLAY (4,0)

This appendix contains the documentation of OVERLAY (4,0), the earthwork analysis. Within this overlay, the earthwork data is decoded, end areas and volumes for a zero thickness pavement are calculated, and a cost summary is printed. If approach zones are included, they are analyzed similarly to the pavement sections. The end areas, written on a tape, are later altered in OVERLAY (3,0) and (6,0) to account for the actual pavement thickness.

EARTH

Purpose

EARTH is the driver of OVERLAY (4,0). It calls other routines for decoding the input and calculating end areas. EARTH also calculates earthwork volumes.

Formal Parameters

The header card for EARTH is:

PROGRAM EARTH.

Description

EARTH calculates earthwork volumes using the average end area method. Areas of cut or fill are calculated perpendicularly to the profile grade line (pavement section centerline) at regular intervals. The volume of earthwork between these end areas is calculated and saved as either cut or fill. If approach zones are input, the variables are reinitialized and the process is repeated, with only cut volumes saved. Figure E1 is a descriptive flowchart.

Variables

Variable	Location	Usage
APREND(9,3)	/ZONES/	NA
APRSTR(9,3)	/ZONES/	NA
APTOT	/ZONES/	NA
APWID(9)	/ZONES/	NA

Variable	Location	Usage
AREA1		End area used for volume calculations, difference of template area and terrain area, converted to square yards and written on TAPE2 for the pavement section, on TAPE3 for approach zones (see Figure E2).
AREA2		Same as AREA1, other end.
COSPGL	/ /	Cosine of the angle between the terrain data centerline and the profile grade line.
CUTCOST	/ /	NA
CUTNET	/ /	Volume of cut (cu yd).
CUTPRCE	/TSV/	NA
CVOL(100)	/PLOTS/	Summation of earthwork volume (cu yd) at each prism, or end area.
DIS		T.V.
DIST(100)	/PLOTS/	Distance from the start of the profile grade line to the location of the volume summation, CVOL.
EARTHWK	/RL1/	Earthwork code: 0 = no 1 = pavement only 2 = pavement plus approach zones. Number >5 = fixed cost.
ECOST	/ /	NA
ELIMHI	/ /	NA
ELIMLO	/ /	NA
ERCOST	/TSV/	NA
FACTOR	/RL2/	NA
FILCOST	/ /	NA
FILLNET	/ /	Volume of fill (cu yd).
FILPRICE	/TSV/	NA
HYPGL		Length of profile grade line (ft).

Variable	Location	Usage
IDENT(3)	/RL1/	NA
IEXTRAP	/ /	NA
IND	/ /	NA
IP	/PLOTS/	Number of members of CVOL and DIST.
IPLOT	/PLOTS/	Equals one if mass diagram is to be plotted.
IROW	/ /	Initialized to zero.
ISCNT		Counts the number of prisms.
JACK	/TMPL/	NA
KAPR		Counts the number of approach zones.
KAPRCNT	/ACNT/	Same as KAPR.
K4	/RL2/	NA
K7	/RL2/	NA
NAPR	/ZONES/	Number of approach zones input.
NPGL	/ /	Initialized to zero.
NTMP	/ /	Initialized to zero.
PGL(20,2)	/ /	NA
PGLA		Coordinate in the "a" direction of the point on the profile grade line under consideration, relative to the terrain centerline (see Figure E3).
PGLB		Same as PGLA, in the "b" direction.
POINT		Distance from the start of the profile grade line to the location of the end area to be calculated (see Figure E3).
PSTEP	/TSV/	Distance between end areas for volume calculations.
RELAREA	/ /	NA

Variable	Location	Usage
RUNE(3)	/ /	Array containing profile grade line information: RUNE(1) is the ordinate of the end of the line, relative to the terrain data centerline; RUNE(2) is the abscissa; RUNE(3) is the elevation of this point.
RUNS(3)	/ /	Same as RUNE, for the beginning of the line.
SEGBEG	/ /	Distance from the start of the profile grade line at which earthwork calculations begin.
SEGEND	/ /	Same as SEGBEG, for the end of calculations.
SINPGL	/ /	Same as COSPGL, sine of the angle.
SPSTEP	/ /	Initialized to 10E50.
SWID	/TMPL/	NA
TER(50,40,2)	/ /	NA
THCK	/TSV/	NA
TLSTART(2)	/ /	NA
TLSTOP(2)	/ /	NA
TMP(20,2)	/ /	NA
TWOCL	/TMPL/	NA
VL		Volume (cu yd) of a prism--negative if cut, positive if fill.
VOL		T.V.
WHERE(50)	/ /	NA
ZONSTEP(9)	/ZONES/	NA

Common Blocks

The common blocks for EARTH are PLOTS, RL1, TMPL, TSV, ZONES, ACNT, and blank common.

Tapes

TAPE2 - writes end areas (sq yd) for the pavement section.
TAPE3 - Writes end areas (sq yd) for the approach zones.
TAPE11 - writes summary to the user.

Traceback

EARTH is called by MAIN as the driver of OVERLAY (4,0), and calls ERROR, INPUT, LPLOT, PRICE, SQRT (CDC Library), TERAREA, TMPAREA, ZONE, ZPRICE, and the inline function ABS.

Illustrations

Figure E1 is a descriptive flowchart of EARTH. Figure E2 shows how the end areas are calculated. Figure E3 illustrates the dimensioning used in EARTH.

References

None.

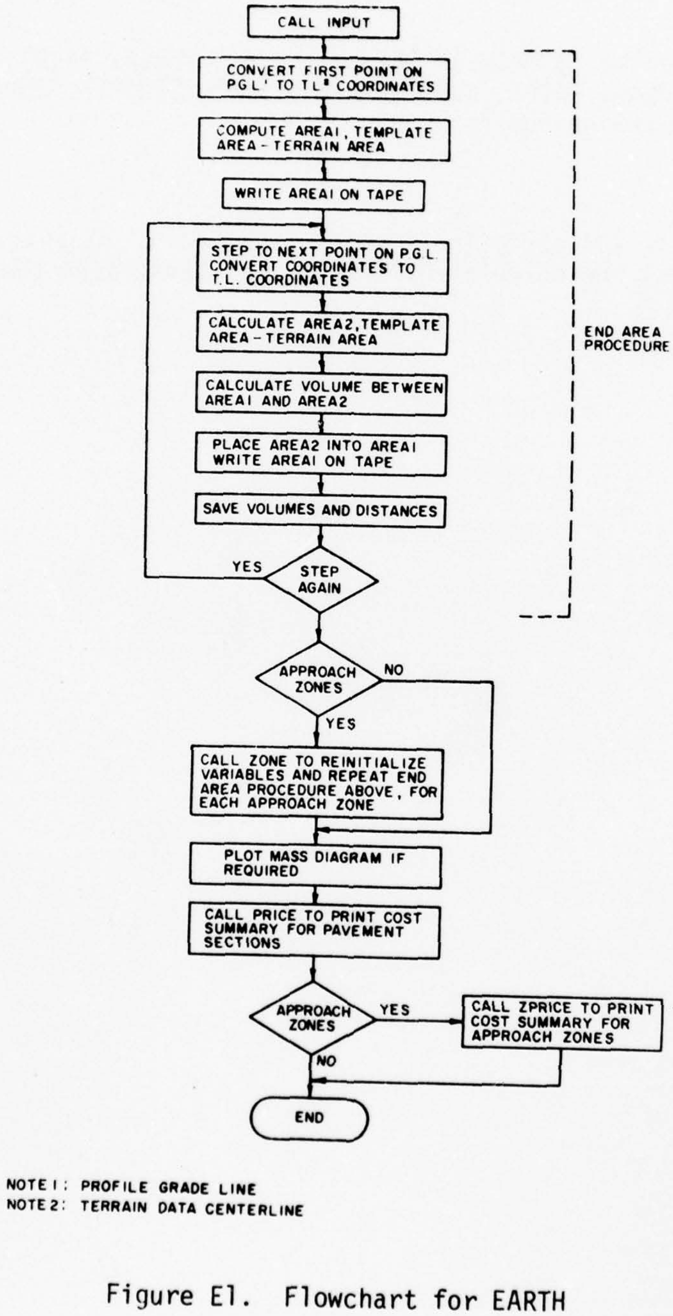

Figure E1. Flowchart for EARTH

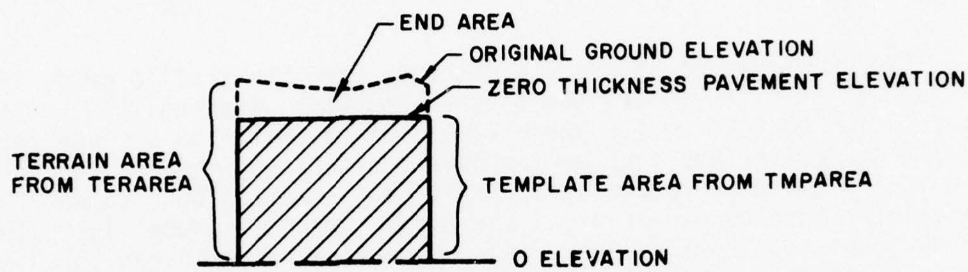

Figure E2. End area, cross-section view.

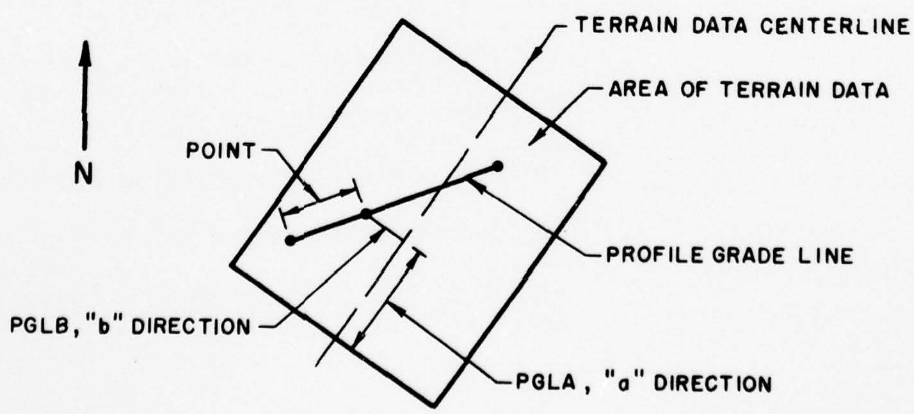

Figure E3. Coordinate system.

TERAREA

Purpose

This function returns the terrain area for a given section.

Formal Parameters

The header card for TERAREA appears as follows:

FUNCTION TERAREA(PGLA,PGLB).

Description

TERAREA first determines the distance from the profile grade line to the left hand (negative) end of the template. Knowing this point and its relation to the profile grade line, and the relation between the profile grade line and the terrain data coordinates, the "a" and "b" coordinates of the template are calculated. Function ELEV calculates the original ground elevation of the point. Moving to the right along the pavement section (in plan view), subroutine NXTPNT finds the distance to the next point, the coordinates are calculated, and ELEV finds the original ground elevation. Between these two points and elevation 0.0, the vertical area is calculated by the trapezoidal formula. This procedure is repeated along the pavement section until the right hand end of the template is reached. All the areas are summed, and the total is returned as the terrain area for a given section (see Figures E3, E4, and E5).

Variables

Variable	Location	Usage
AP		"a" coordinate of one point on section.
APO		"a" coordinate of second point on section.
AREA		Cumulative terrain area (SE).
BP		"b" coordinate of one point on section.
BPO		"b" coordinate of second point on section.
COSPGL	/ /	Cosine of the angle between the terrain data centerline and the profile grade line.
CUTCOST	/ /	NA
CUTNET	/ /	NA

Variable	Location	Usage
ECOST	/ /	NA
ELIMHI	/ /	NA
ELIMLO	/ /	NA
EV		Elevation (ft) of one point on the section.
EVO		Elevation (ft) of second point on the section.
FILCOST	/ /	NA
FILLNET	/ /	NA
IEXTRAP	/ /	NA
IND	/TMPL/	NA
IROW	/ /	NA
JACK	/TMPL/	NA
NPGL	/ /	NA
NTMP	/ /	Number of points defining the template.
PGL(20,2)	/ /	NA
PGLA	FP	"a" coordinate of point on profile grade line through which the pavement section being analyzed passes.
PGLB	FP	Same as PGLB, "b" coordinate.
RELAREA	/ /	NA
RUNE(3)	/ /	NA
RUNS(3)	/ /	NA
SEGBEG	/ /	NA
SEGEND	/ /	NA
SINPGL	/ /	Same as COSPGL, sine of the angle.
SPSTEP	/ /	NA

Variable	Location	Usage
STEP		Distance (ft), determined by subroutine NXTPNT, from last point on the pavement section to the new point.
SWID	/TMPL/	Width (yd) of template.
TEND		Distance (ft) from the profile grade line to the right end of the template.
TER(50,40,2)	/ /	NA
TERAREA		Function value returned, terrain area (sq ft).
TLSTART(2)	/ /	NA
TLSTOP(2)	/ /	NA
TMP(20,2)	/ /	Array containing the coordinates defining the template: TMP(I,1) is the distance from the profile grade line to the Ith template point, positive if right, negative if left (looking upstation); and TMP(I,2) is the elevation of this point relative to the elevation of the profile grade line.
TSTRT		Distance of the point from the profile grade line, along the pavement section.
TWOCL	/TMPL/	NA
WHERE(50)	/ /	NA

Common Blocks

The common blocks in TERAREA are TMPL and blank common.

Tapes

None.

Traceback

TERAREA is called by EARTH and calls ELEV, NXTPNT, and the inline function ABS.

Illustrations

Figure E4 is a flowchart of TERAREA.

Figure E5 shows a plan and a section view of the terrain calculations.

References

None.

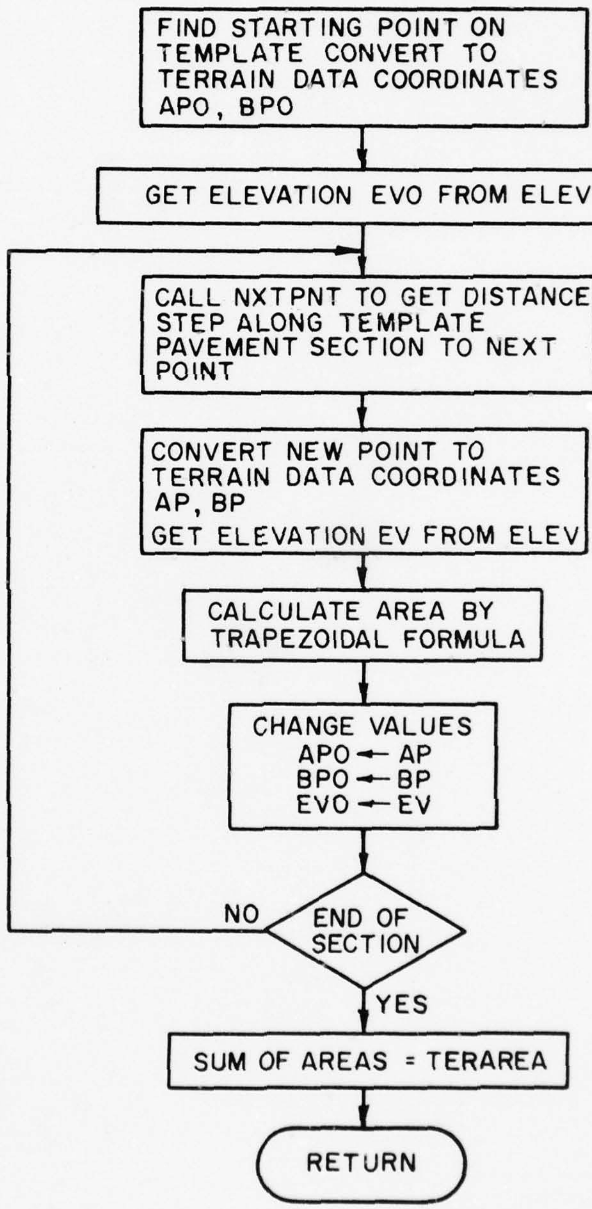

Figure E4. Flowchart of TERAREA.

AD-A067 691 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAI--ETC F/G 13/2
SYSTEMS APPROACH TO LIFE-CYCLE DESIGN OF PAVEMENTS. VOLUME II. --ETC(U)
JAN 79 E S LINDOW

UNCLASSIFIED CERL-TR-M-253-VOL-2 NL

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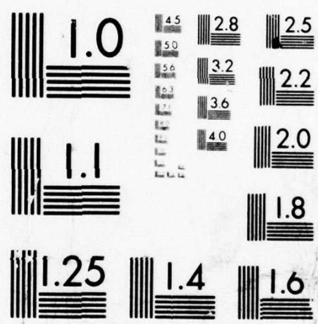
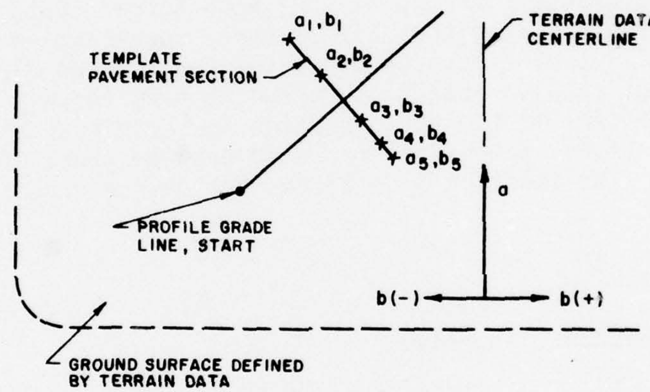
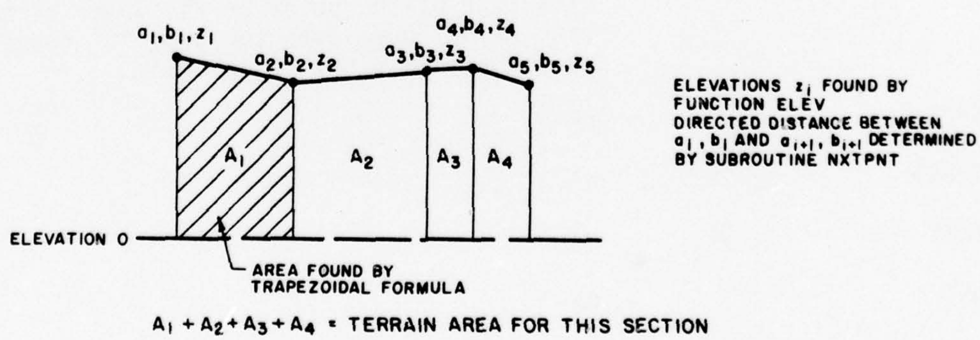


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



PLAN VIEW



SECTION VIEW

Figure E5. Views of terrain area.

ELEV

Purpose

This function determines the elevation of the point defined by the formal parameters.

Formal Parameters

The header card for ELEV appears as follows:

FUNCTION ELEV(A,B).

Description

This routine brackets the point (AB) with terrain data points, then interpolates or extrapolates (if allowed) to determine the elevation of (AB). ELEV finds the cross-section rows on either side ("a" direction) of (A,B). SEARCH is called to find terrain data points on either side of (AB) in the "b" direction for each bracketing row. The elevation of (A,B) is then interpolated between these four points (see Figure E6). The function also allows for unique conditions and extrapolation.

Variables

Variable	Location	Usage
A	FP	Coordinate in the "a" direction for the point whose elevation is desired.
B	FP	Same as for A, but in the "b" direction.
BEG		Elevation of the point on the lower of the two bracketing rows, with the same "b" coordinate as point (A,B) (see Figure E6).
COSPGL	/ /	NA
CUTCOST	/ /	NA
CUTNET	/ /	NA
ECOST	/ /	NA
ELEV		Function value, elevation of point (A,B).
ELIMHI	/ /	Highest elevation allowed; not operable for approach zones.

Variable	Location	Usage
ELIMLO	/ /	Lowest evaluation allowed; not operable for approach zones.
END		Same as BEG, on the higher of the two bracketing rows.
FILCOST	/ /	NA
FILLNET	/ /	NA
I		T.V.
IBEG		Index of the lower of the bracketing cross-section rows.
IEND		Index of the higher of the bracketing cross-section rows.
IEXTRAP	/ /	Extrapolation code: 0 = extrapolation allowed, no message 1 = extrapolation allowed, message printed 2 = no extrapolation allowed.
IROW	/ /	Number of cross-section rows.
KAPRCNT	/ACNT/	Number of the approach zone being analyzed; turns off elevation limits.
LESS		Index of the lower "b" value on a cross-section row.
LESSB		Same as LESS.
LESSE		Same as LESS.
MORE		Index of the higher "b" value on a cross-section row.
MOREB		Same as MORE.
MOREE		Same as MORE.
NPGL	/ /	NA
NTMP	/ /	NA
PGL(20,2)	/ /	NA

Variable	Location	Usage
RELAREA	/ /	NA
RUNE(3)	/ /	NA
RUNS(3)	/ /	NA
SEGBEG	/ /	NA
SEGEND	/ /	NA
SINPGL	/ /	NA
SPSTEP	/ /	NA
TER(50,40,2)	/ /	Array containing the cross-section data: TER(IJ1) is the transverse distance from the terrain data centerline to the elevation point (right is positive, left is negative, looking upstation) for the Jth cross-section along the terrain line; TER(I,J,2) is the elevation of point (IJ1).
TLSTART(2)	/ /	NA
TLSTOP(2)	/ /	NA
TMP(20,2)	/ /	NA
WHERE(50)	/ /	Distance from the start of the terrain data centerline to the Ith cross-section.

Common Blocks

The common blocks in ELEV are ACNT and blank common.

Tapes

None.

Traceback

ELEV is called by TERAREA and calls ERROR, SEARCH, and the inline function QINT defined in this routine.

Illustrations

Figure E6 shows the bracketing method used in ELEV.

References

None.

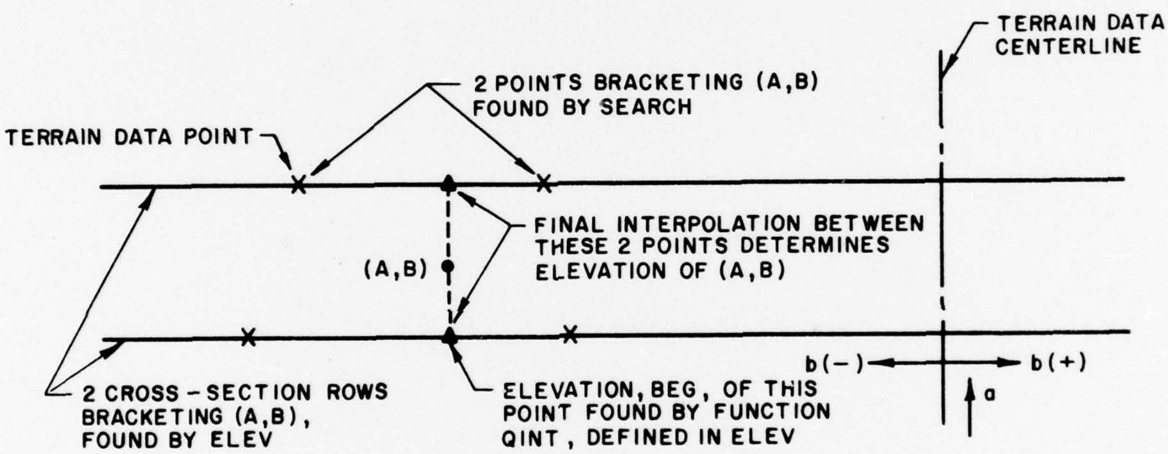


Figure E6. Elevation determination procedure.

SEARCH

Purpose

This routine finds the indices of the points on a cross-section row which bracket a given value.

Formal Parameters

The header card for SEARCH appears as follows:

SUBROUTINE SEARCH(LROW,B,LESS,MORE).

Description

The subroutine checks through a given cross-section row to find the indices of terrain data points which bracket a given coordinate in the "b" direction (see Figure E7).

Variables

Variable	Location	Usage
B	FP	Coordinate in the "b" direction which is to be bracketed.
COSPL	/ /	NA
CUTCOST	/ /	NA
CUTNET	/ /	NA
ECOST	/ /	NA
ELIMHI	/ /	NA
EUMLO	/ /	NA
FILCOST	/ /	NA
FILLNET	/ /	NA
I		T.V.
IEXTRAP	/ /	Extrapolation code: 0 = extrapolation allowed, no message 1 = extrapolation allowed, message printed 2 = no extrapolation allowed.

Variable	Location	Usage
IROW	/ /	NA
J		T.V.
K		T.V.
KKNT		Counter used to determine if two data points exist in a cross-section row.
LESS	FP	Index of a terrain data point on a given cross-section row which is less than a given coordinate.
LROW	FP	Index of the cross-section row.
MORE	FP	Same as LESS, greater than a given coordinate.
NPGL	/ /	NA
NTMP	/ /	NA
PGL(20,2)	/ /	NA
RELAREA	/ /	NA
RUNE(3)	/ /	NA
RUNS(3)	/ /	NA
SEGBEG	/ /	NA
SEGEND	/ /	NA
SINPGL	/ /	NA
SPSTEP	/ /	NA
TER(50,40,2)	/ /	Array containing the cross-section data: TER(IJ1) is the transverse distance from the terrain data centerline to the elevation point (right is positive, left is negative, looking upstation) for the Jth cross-section point on the Ith cross-section along the terrain line; TER(I,J,2) is the elevation of point (IJ1).
TLSTART(2)	/ /	NA

Variable	Location	Usage
TLSTOP(2)	/ /	NA
TMP(20,2)	/ /	NA
WHERE(50)	/ /	NA

Common Blocks

The common block in SEARCH is blank common.

Tapes

None.

Traceback

SEARCH is called by ELEV and NXTPNT, and calls ERROR.

Illustrations

Figure E7 illustrates SEARCH.

References

None.

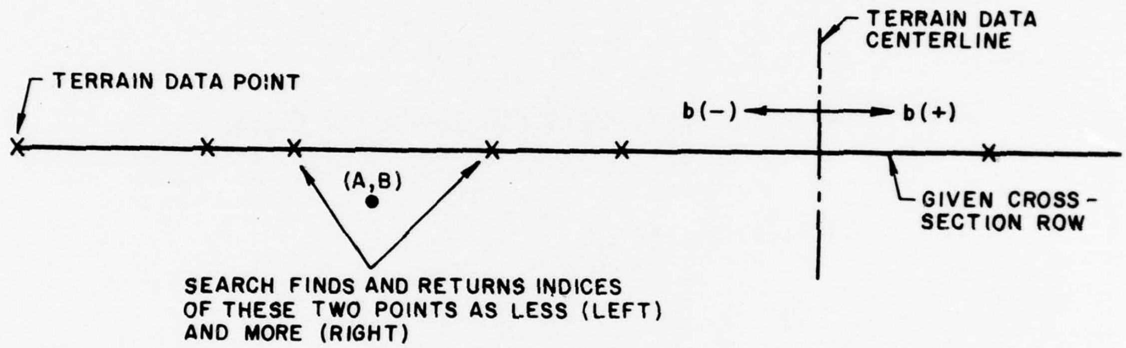


Figure E7. SEARCH method.

INPUT

Purpose

This subroutine reads the input data from TAPE2, assigns the data to internal variables, and does minor data conversion.

Formal Parameters

The header card for INPUT appears as follows:

SUBROUTINE INPUT.

Description

This subroutine reads the earthwork fixed format cards from TAPE2 and identifies each card type from a code in the first columns of the card. The data from the cards are assigned to internal variables. When the RUN card is read, it is assumed to be the last data card. A card that does not match the card type code causes "UNRECOGNIZABLE STATEMENT" to be printed, and a flag to terminate the program is set. The terrain data, template data, and profile grade line break point data are sorted; the coordinates of the profile grade line are related to the terrain centerline; and the relative area of the template (zero in LIFE2) is calculated.

Variables

Variable	Location	Usage
APREND(9,3)	/ZONES/	Array containing approach zone information APREND(I,1) is the North-South coordinate of the end of approach zone I. APREND(I,2) is the East-West coordinate of the end of approach zone I. APREND(I,3) is the elevation (ft) of the end of approach zone I.
APRSTR(9,3)	/ZONES/	Same as APREND, but for the start of an approach zone.
APTOT	/ZONES/	NA
APWID(9)	/ZONES/	Array containing the width of each approach zone.
A1		T.V., represents the new ordinate of the start of the profile grade line. The original coordinate, as input, was in relation to the

Variable	Location	Usage
		north-south line; the new ordinate is related to the terrain data axis (see Figure E9).
A2		Same as A1, but for the end of the profile grade line (see Figure E9).
B1		T.V., represents the new abscissa of the start of the profile grade line. The original coordinate, as input, was in relation to the east-west line; the new abscissa is related to the terrain data axis (see Figure E9).
B2		Same as B1, but for the end of the profile grade line (see Figure E9).
COSA		Cosine of the angle between the north-south line and the terrain data centerline (see Figure E9).
COSPGL	/ /	Cosine of the angle between the terrain data centerline and the profile grade line.
CUTCOST	/ /	NA
CUTNET	/ /	NA
CUTPRCE	/TSV/	Cost/cu yd for excavation.
CVOL(100)	/PLOTS/	NA
DELHI		Increase in elevation (ft) allowed above the highest terrain data elevation due to interpolation or extrapolation.
DELLO		Decrease in elevation (ft) allowed below the lowest terrain data elevation due to interpolation or extrapolation.
DIST(100)	/PLOTS/	NA
EARTHWK	/RL1/	Earthwork code, redefined to exclude approach zone calculations if approach zone data is not complete.
ECOST	/ /	NA
ELEVHI		Highest elevation found in terrain data.
ELEVLO		Lowest elevation found in terrain data.

Variable	Location	Usage
ELIMHI	/ /	Highest elevation allowed in interpolation or extrapolation.
ELIMLO	/ /	Lowest elevation allowed in interpolation or extrapolation.
ERCOST	/TSV/	NA
FACTOR	/RL1/	NA
FILCOST	/ /	NA
FILLNET	/ /	NA
FILPRCE	/TSV/	Cost/cu yd for fill.
HYP		Length of terrain data centerline.
HYPGL		Length of profile grade line.
I		T.V.
IDENT(3)	/RL1/	NA
IEXTRAP	/ /	Extrapolation code: 0 = X = allow extrapolation, no message 1 = E = allow extrapolation, write message 2 = Q = no extrapolation allowed.
IND	/TMPL/	NA
IP	/PLOTS/	
IPGBRK		T.V., counter.
IPGL		Switch indicating that the end points of the profile grade line have been defined.
IPLOT	/PLOTS/	Indicates if mass diagram is to be plotted if equal to one.
IROW	/ /	Number of cross-sections along the terrain data centerline.
ITD		T.V.
ITMP		Number of points defining the template.

Variable	Location	Usage
J		T.V.
JA		Approach zone number.
JACK	/TMPL/	NA
JAKNT		Number of approach zone coordinates read.
JB		Approach zone number.
JBKNT		Number of approach zone lengths and widths read.
JEX		T.V.
JPL		T.V.
K		T.V.
KCNT		T.V.
KTEST(2)		Array containing the array members of LINE to be checked for data.
KTMP		Number of area calculations for RELAREA.
K4	/RL1/	NA
K7	/RL1/	NA
LINE(8)		Array containing 10 card columns per member from the input record.
M		T.V.
MAPE		T.V.
MAPR		T.V.
N		T.V.
NAPR	/ZONES/	Number of approach zones read.
NOGO		Signals that an unrecognizable statement was read.
NPGL	/ /	Number of profile grade line break points.
NTMP	/ /	Number of points defining the template.

Variable	Location	Usage
PGL(20,2)	/ /	Array containing profile grade line break points: PGL(I,1) is the distance from the profile grade line starting point to the Ith break point; PGL(I,2) is the elevation of the Ith break point.
PGLT(3,2)		T.V.
PSTEP	/TSV/	Length of the prism (distance along profile grade line between end area calculations) for the volume calculations (ft).
RELAREA	/ /	Relative area of the template, equal to zero for LIFE2 (zero thickness pavement).
RUNE(3)	/ /	Array containing profile grade line information: RUNE(1) is the ordinate of the end of the line, first relative to north-south, and finally, relative to the terrain data centerline; RUNE(2) is the abscissa of the end of the line, first relative to east-west, and finally, relative to the terrain data centerline; RUNE(3) is the elevation of this point.
RUNS(3)	/ /	Same as RUNE, except for the beginning of the line.
SEGBEG	/ /	Distance from start of profile grade line at which earthwork calculations begin.
SEGEND	/ /	Same as SEGBEG, for end of calculations.
SINA		Same as COSA, sine of the angle.
SINPGL	/ /	Same as COSPGL, sine of the angle.
SPSTEP	/ /	T.V.
SWID	/TMPL/	NA

Variable	Location	Usage
TER(50,40,2)	/ /	Array containing the cross-section data: TER(IJ1) is the transverse distance from the terrain data centerline to the elevation point (right is positive, left is negative, looking upstation) for the Jth cross-section point on the Ith cross-section along the terrain line; TER(IJ2) is the elevation of point (IJ1).
THCK	/TSV/	NA
TLSTART(2)	/ /	TLSTART(1) is the north-south coordinate of the terrain data centerline. TLSTART(2) is the east-west coordinate.
TLSTOP(2)	/ /	Same as TLSTART, but for the end of the terrain data centerline.
TMP(20,2)	/ /	Array containing the coordinates defining the template: TMP(I,1) is the distance from the profile grade line to the Ith template (looking upstation); and TMP(I,2) is the elevation of this point relative to the elevation of the profile grade line.
TMPT(3,2)		T.V.
TPSTEP		T.V.
TREAD(4)		Array containing cross-section data from a survey: TREAD(1) is the distance along the terrain data centerline from the start to the cross-section; TREAD(2) is the transverse distance from the terrain data centerline to the elevation point, positive if to the right, negative if to the left (looking upstation); TREAD(3) is the height of instrument (H.I.) initially, changed to the actual elevation of the point; TREAD(4) is the rod reading.
TSEGB		T.V.
TSEGE		T.V.

Variable	Location	Usage
TTER(3,2)		T.V.
TWOCL	/TMPL/	NA
WHERE(50)	/ /	Distance from the start of the terrain data centerline to the Ith cross-section.
ZONSTEP(9)	/ZONES/	Length (ft) of the prism for volume calculation for each approach zone.

Common Blocks

The common blocks in INPUT are PLOTSRL1,TMPL,TSV,ZONES, and blank common.

Tapes

Tapes used by INPUT are:

TAPE2 -- contains the earthwork data as read off the input cards.
TAPE4 -- writes messages to the user, and echo prints the input.

Traceback

INPUT is called by EARTH and calls EOF,ERROR,SORTA,SORTD, and SQRT.

Illustrations

Figure E8 is a descriptive flowchart of INPUT.

Figures E9 and E10 graphically show some of the terminology and dimensioning.

References

None.

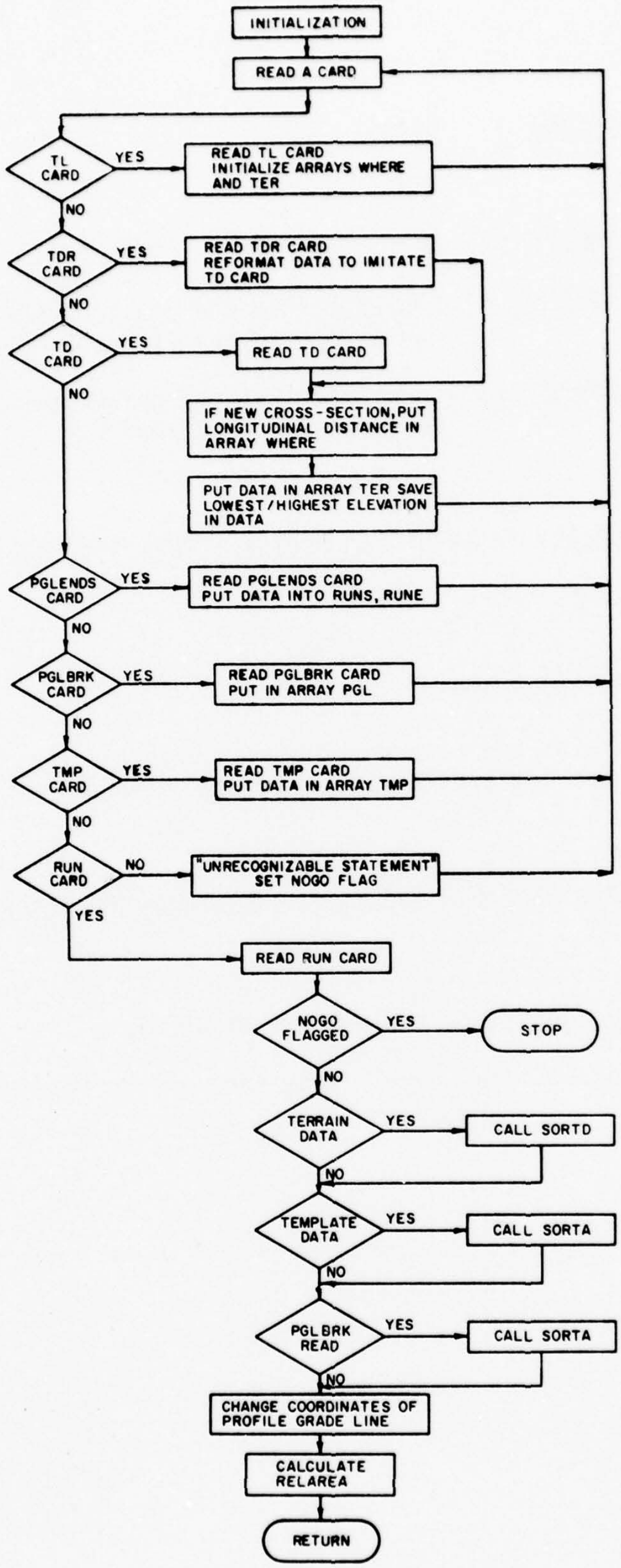


Figure E8. Flowchart of INPUT.

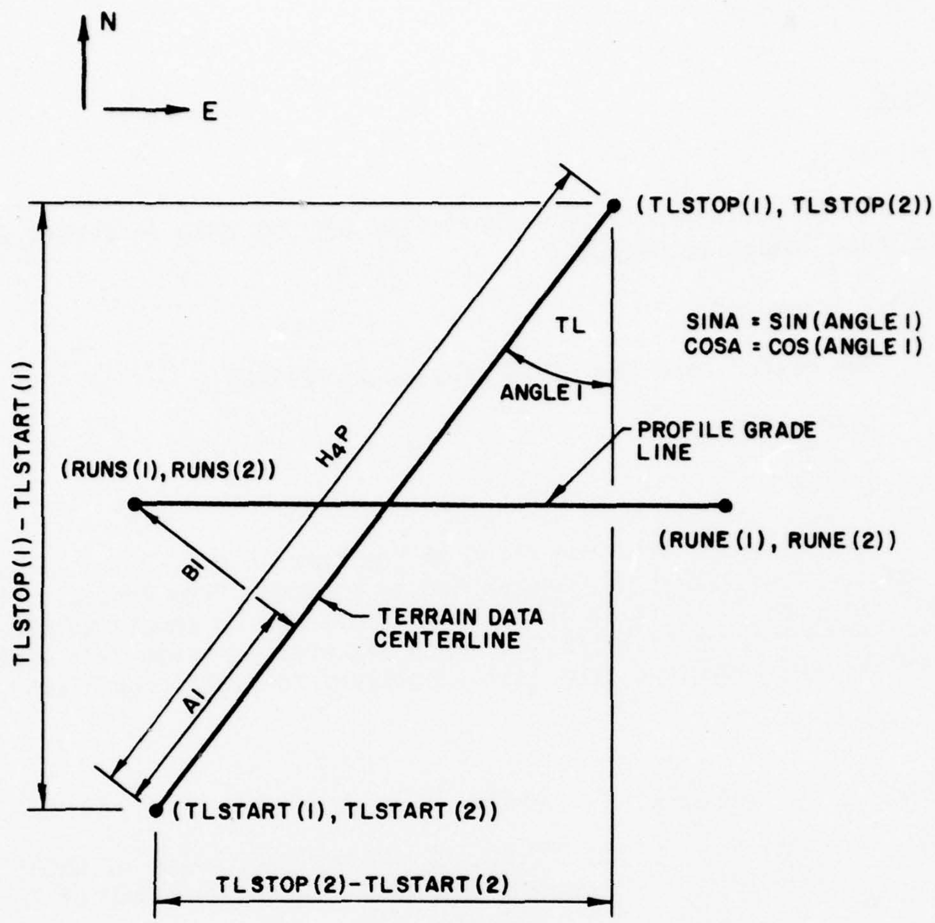


Figure E9. Earthwork terrain data.

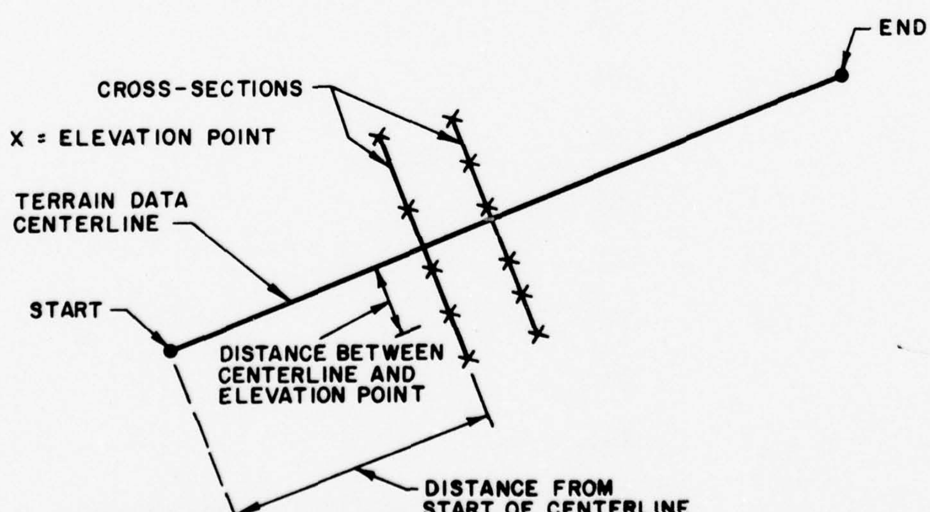


Figure E10. Earthwork cross-section data.

SORTD

Purpose

This routine numerically sorts the terrain data in arrays WHERE and TER from lowest to highest.

Formal Parameters

The header card for SORTD appears as follows:

SUBROUTINE SORTD.

Description

The distances from the start of the terrain centerline to the cross-sections, WHERE(I), are sorted to progress from lowest to highest. The cross-section data in TER(IJK) is reordered to remain consistent with the new order of WHERE(I). Then the cross-section data within TER(IJK) are reordered from left (negative) to right (positive).

Variables

Variable	Location	Usage
BIG		T.V., is the smallest value of WHERE in the first section, and the largest value of TER in the last section.
COSPGL	/ /	NA
CUTCOST	/ /	NA
CUTNET	/ /	NA
ECOST	/ /	NA
ELIMHI	/ /	NA
ELIMLO	/ /	NA
FILCOST	/ /	NA
FILLNET	/ /	NA
I		T.V.
IBIG		T.V. flags the smallest member of WHERE in the first section, and the largest member of TER in the last section.

Variable	Location	Usage
IEXTRAP	/ /	NA
IROW	/ /	Number of rows of cross-sections.
J		T.V.
K		T.V.
KK		T.V.
KROW		T.V.
NPGL	/ /	NA
NTMP	/ /	NA
PGL(20,2)	/ /	NA
RELAREA	/ /	NA
RUNE(3)	/ /	NA
RUNS(3)	/ /	NA
SEGBEG	/ /	NA
SEGEND	/ /	NA
SINPGL	/ /	NA
SPSTEP	/ /	NA
TEM		T.V.
TER(50,40,2)	/ /	Array containing the cross-section data: TER(I,J,1) is the transverse distance from the terrain data centerline to the elevation point (right is positive, left is negative, looking upstation) for the Jth cross-section point on the Ith cross-section along the terrain line; TER(IJ2) is the elevation of point (IJ1).
TLSTART(2)	/ /	NA
TLSTOP(2)	/ /	NA
TMP(20,2)	/ /	NA

Variable	Location	Usage
WHERE(50)	/ /	Distance from the start of the terrain data centerline to the Ith cross-section.

Common Blocks

This routine has only blank common.

Tapes

None.

Traceback

This subroutine is called by INPUT and calls ERROR.

Illustrations

None.

References

None.

SORTA

Purpose

This subroutine reorders the array ARR from lowest to highest.

Formal Parameters

The header card for SORTA appears as follows:

SUBROUTINE SORTA (ARR,NUM)

Description

SORTA takes the formal parameter array ARR and reorders ARR(I,1) from the lowest (may be negative) to the highest value. ARR(I,2) is reordered to remain consistent with ARR(I,1).

Variables

Variable	Location	Usage
ARR(20,2)	FP	Array to be sorted. ARR(I,1) is sorted from the lowest (may be negative) to the highest value. ARR(I,2) is not sorted, but only reordered to be consistent with ARR(I,1).
I		T.V.
IS		T.V.
J		T.V.
K		T.V.
LIM		T.V., equal to NUM.
LIM1		T.V.
NUM	FP	Number of members in the first index of ARR(I,1).
SMALL		T.V.
TEM		T.V.

Common Blocks

None.

Tapes

None.

Traceback

SORTA is called by INPUT and calls ERROR.

Illustrations

None.

References

None.

ERROR

Purpose

This subroutine provides various informational and error messages to the user and may stop the program.

Formal Parameters

The header card for ERROR appears as follows:

SUBROUTINE ERROR(I).

Description

ERROR uses the formal parameter I to determine the type of error encountered. An error or informative message is written, and the program may be terminated, depending on the error type. If the program is to be stopped, NAMELIST BUG is written. This lists the current values of selected variables as defined in NAMELIST. At the end of a successful earthwork analysis, ERROR may be called to print summary messages.

Variables

Variable	Location	Usage
COSPGL	/ /	NA
CUTCOST	/ /	NA
CUTNET	/ /	NA
CUTPRCE	/TSV/	NA
ECOST	/ /	NA
ELIMHI	/ /	NA
ELIMLO	/ /	NA
ERCOST	/TSV/	NA
FILCOST	/ /	NA
FILLNET	/ /	NA
FILPRCE	/TSV/	NA
I	FP	Index to flag the type of error.

Variable	Location	Usage
IEXTRAP	/ /	Extrapolation code: 0 = allow extrapolation, no message 1 = allow extrapolation, write message 2 = no extrapolation allowed.
IROW	/ /	NA
IXCNT		Counts the number of extrapolations that have occurred.
LIMHI		Counts the number of times that the highest elevation limit has been used.
LIMLO		Same as LIMHI, for lowest elevation limit.
NPGL	/ /	NA
NTMP	/ /	NA
PGL(20,2)	/ /	NA
PSTEP	/TSV/	NA
RELAREA	/ /	NA
RUNE(3)	/ /	NA
RUNS(3)	/ /	NA
SEGBEG	/ /	NA
SEGEND	/ /	NA
SINPGL	/ /	NA
SPSTEP	/ /	NA
TER(50,40,2)	/ /	NA
THCK	/TSV/	NA
TLSTART(2)	/ /	NA
TLSTOP(2)	/ /	NA
TMP(20,2)	/ /	NA

Variable	Location	Usage
WHERE(50)	/ /	NA

Common Blocks

The common blocks are TSV and blank common.

Tapes

TAPE4 -- writes error and information messages to the user.

Traceback

ERROR is called by EARTH, INPUT, SEARCH, ELEV, and NXTPNT.

Illustrations

None.

References

None.

LPLOT

Purpose

This subroutine sets up the call to the plotting routine for the earthwork mass diagram.

Formal Parameters

The header card for LPLOT appears as follows:

SUBROUTINE LPLOT.

Description

LPLOT writes comments and sets up the call to STPLT1 (1,DIST,CVOL,IP,1H*,6,6HVOLUME) for plotting the mass diagram. The first parameter, 1, indicates that the graph is only one page long. The fifth parameter, 1H*, specifies that * will represent the data points on the graph. The sixth and seventh parameters are, respectively, the number of characters in the label and the label to be printed vertically to the left of the graph. The remaining parameters are defined in the *Variables* section.

Variables

Variable	Location	Usage
CVOL(100)	/PLOTS/	This array contains the cumulative earthwork volumes (cu yd) in each prism. Cut is negative, and fill is positive.
DIST(100)	/PLOTS/	This array contains the distance from the start of the profile grade line to the end of each prism, and corresponds to CVOL.
IP	/PLOTS/	Number of members of CVOL and DIST.
IPLOT	/PLOTS/	NA

Common Blocks

LPLOT has the common block PLOTS.

Tapes

The tape used by LPLOT is:

TAPE11--contains the mass diagram plot.

Traceback

LPLOT is called by EARTH and calls STPLT1.

Illustrations

None.

References

None.

TMPAREA

Purpose

This function returns the template area for a given point on the profile grade line.

Formal Parameters

The header card for TMPAREA appears as follows:

FUNCTION TMPAREA(RELDST).

Description

Knowing the location of the template along the profile grade line, TMPAREA determines elevations on the cross section at this location, considering any break points that exist. The elevation is multiplied by the width of the template to get the template area.

Variables

Variable	Location	Usage
COSPGL	/ /	NA
CUTCOST	/ /	NA
CUTNET	/ /	NA
DIST		Length (ft) of the profile grade line.
ECOST	/ /	NA
ELIMHI	/ /	NA
ELIMLO	/ /	NA
FILCOST	/ /	NA
FILLNET	/ /	NA
I		T.V.
IEXTRAP	/ /	NA
IROW	/ /	NA
NPGL	/ /	Number of profile grade line break points.

Variable	Location	Usage
NTMP	/ /	Number of points defining the template.
PGL(20,2)	/ /	Array containing profile grade line break points: PGL(I,1) is the distance from the profile grade line starting point to the Ith break point. PGL(I,2) is the elevation of the Ith break point.
QAREA		Width of template (ft).
RELAREA	/ /	Relative area of the template, equal to zero for LIFE2.
RELDST	FP	Distance (ft) from the start of the profile grade line to the location where the template area is desired.
RUNE(3)	/ /	Array containing profile grade line information. RUNE(1) is the ordinate of the end of the line, first relative to north-south, and finally, relative to the terrain data centerline; RUNE(2) is the abscissa of the end of the line, first relative to east-west, and finally, relative to the terrain data centerline.
RUNS(3)	/ /	Same as RUNE, for the beginning of the line.
SEGBEG	/ /	NA
SEGEND	/ /	NA
SINPGL	/ /	NA
SPSTEP	/ /	NA
TER(50,40,2)	/ /	NA
TLSTART(2)	/ /	NA
TLSTOP(2)	/ /	NA
TMP(20,2)	/ /	Array containing the coordinates defining the template: TMP(I,1) is the distance from the profile grade line to the Ith template point--positive if right, negative if left

Variable	Location	Usage
		(looking upstation); TMP(I,2) is the elevation of this point relative to the elevation of the profile grade line.
TMPAREA		Function value returned, template area (sq ft).
WHERE(50)	/ /	NA

Common Blocks

The common block in TMPAREA is blank common.

Tapes

None.

Traceback

TMPAREA is called by EARTH and calls ERROR and SQRT (CDC Library).

Illustrations

None.

References

None.

NXTPNT

Purpose

This routine determines the distance to step along the pavement section for terrain area calculations.

Formal Parameters

The header card for NXTPNT appears as follows:

SUBROUTINE NXTPNT(A,B,STEP).

Description

NXTPNT is the procedure used to determine the distance from point (AB) on the pavement section to the next location of terrain area calculations. Terrain cross-section rows are found which bracket point (A,B) in the "a" direction. On these rows, data points are found which bracket (AB) in the "b" direction. Directed distances in the "a" and "b" direction are found between the data points and (AB). From these distances, the minimum non-zero positive distance is used as the step distance. A typical example is shown in Figure E11.

Variables

Variables	Location	Usage
A	FP	Coordinate in the "a" direction of the last point used in the terrain area calculations.
AA		T.V.
B	FP	Same as A, but in the "b" direction.
COSPGL	/ /	Cosine of the angle between the terrain data centerline and the profile grade line.
CUTCOST	/ /	NA
CUTNET	/ /	NA
DIST		T.V.
DIST1		Distance (ft) in the "b" direction.
DIST2		Same as DIST1.
DIST3		Distance (ft) in "a" or "b" direction.

Variables	Location	Usage
DIST4		Same as DIST3
DIST5		Distance (ft) in the "a" direction.
DIST6		Same as DIST5.
ECOST	/ /	NA
ELIMHI	/ /	NA
ELIMLO	/ /	NA
FILCOST	/ /	NA
FILLNET	/ /	NA
I		T.V.
IBEG		Lower bracketing index of cross-section row.
IEND		Higher bracketing index of cross-section row.
IEXTRAP	/ /	Extrapolation code: 0 = extrapolation allowed, no message 1 = extrapolation allowed, message printed 2 = no extrapolation allowed.
IROW	/ /	Number of cross-section rows.
LESS		Index of the lower "b" value on a cross-section row.
LESSE		Same as LESS.
MORE		Index of the higher "b" value on a cross-section row.
MOREB		Same as MORE.
MOREE		Same as MORE.
NPGL	/ /	NA
NTMP	/ /	NA
PGL(20,2)	/ /	NA

Variables	Location	Usage
RELAREA	/ /	NA
RUNE(3)	/ /	NA
RUNS(3)	/ /	NA
SEGBEG	/ /	NA
SEGEND	/ /	NA
SINPGL	/ /	NA
SPSTEP	/ /	NA
STEP	FP	Incremental distance (ft) along pavement section from last point, (AB).
STPMIN		Minimum distance (ft) of increment.
TER(50,40,2)	/ /	Array containing the cross-section data: TER(IJ1) is the transverse distance from the terrain data centerline to the elevation point (right is positive, left is negative, looking upstation) for the Jth cross-section point on the Ith cross-section along the terrain line; TER(IJ2) is the elevation of point (IJ1).
TLSTART(2)	/ /	
TLSTOP(2)	/ /	
TMP(20,2)	/ /	
WHERE(50)		Distance (ft) from the start of the terrain data centerline to the Ith cross-section.

Common Blocks

The common block in NXTPNT is blank common.

Tapes

None.

Traceback

NXTPNT is called by TERAREA and calls ERROR, SEARCH, and the inline functions ABS and AMIN1.

Illustrations

Figure E11 illustrates the parameters used in NXTPNT.

References

None.

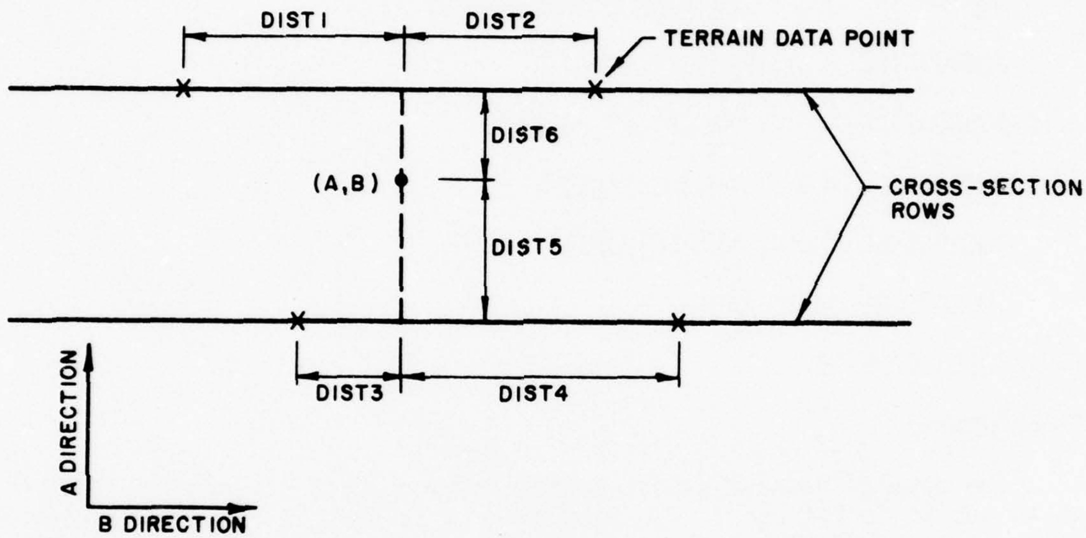


Figure E11. NXTPNT parameters.

SETPLOT PACKAGE

Purpose

The setplot package produces machine plotting on a line printer for the earthwork mass diagram.

Formal Parameters

The header cards for the routines within the setplot package appear as follows:

SUBROUTINE STPLT1(LXYNUMBCDNCHARNHABCD)

SUBROUTINE PLOT1(P1,P2P3,P4P5)

SUBROUTINE PLOT2(IMAGEP1,P2,P3,P4)

SUBROUTINE PLOT3(KARWZNKIMAGE)

SUBROUTINE PLOT4(NNLABELIMAGE)

SUBROUTINE OMIT(IARG)

IDENT COMPSUB.

Description

The setplot package produces the earthwork mass diagram for LIFE2 as an option to the user. The mass diagram is plotted on a grid by the line printer (see Figure E12). The routines contained in this package establish scale and labels for the ordinate and abscissa and individually plot each data point (X(I),Y(I)).

The setplot package operates as follows:

STPLT1 — Called by LPLOT to start the setplot package. Determines the maximum and minimum values for each axis. Determines the length and scale of each axis. Calls PLOT1, PLOT2, PLOT3, and PLOT4.

PLOT 1 — Sets up the grid spacing and the total width and length of the graph image. It also determines the location of the decimal points and the multiplying factors (powers of 10) for values to be printed on the ordinate and abscissa. Calls DASPXXX (entry point of COMPSUB).

PLOT 2 Prepares the grid, examines the maximum and minimum values of the abscissa and ordinate and establishes internally a formula for computing the location in the image region corresponding to the point (X(I),Y(I)).

PLOT 3 Places the specified plotting character (* for LIFE2) in the appropriate position coresponding to the given value of (X(I),Y(I)).

PLOT 4 Writes the image of the completed graph on TAPE11 for subsequent printing off line. A label for the ordinate is printed vertically (one character per line) at the left edge of the page. Values of the abscissa and ordinate are printed at the grid lines outside the bottom and left edges of the graph.

COMPSUB Entry point is DASPXXX. Creates the lines used to make the grids. Written in COMPASS assembly language rather than FORTRAN Extended.

OMIT Not presently used by LIFE2, but retained for possible future applications. Deletes selected sections of the graph.

Complete documentation is provided in the reference for this package.

Variables

Variables used in the SETPLOT package are described in the reference for this section.

Common Blocks

The common blocks for the setplot package are:

STPLT1 - STPCOM

PLOT1 - COMPLOT

PLOT2 - COMPLOT

PLOT3 - COMPLOT

PLOT4 - COMPLOT

OMIT - COMPLOT

COMPSUB - COMPLOT.

Tapes

The tapes used by the various routines are as follows:

OMITCOMPSUB - None.

Others - TAPE11 contains the plot and any messages.

Traceback

STPLT1 is called by LPLOT and calls ALOG10, PLOT1, PLOT2, PLOT3, PLOT4, and the inline functions ABS, AINT, FLOAT, and MOD.

PLOT1 is called by STPLT1 and calls DASPXXX (COMPSUB) and the inline functions ABS, IABS, and SHIFT.

PLOT2 is called by STPLT1.

PLOT3 is called by STPLT1 and calls the inline functions ABS, IABS, and SHIFT.

PLOT4 is called by STPLT1 and calls the inline functions ABS, IABS, MOD, and SHIFT.

OMIT is not called at present.

COMPSUB is called by PLOT1.

Illustrations

Figure E12 is an example of the setplot package output.

References

None

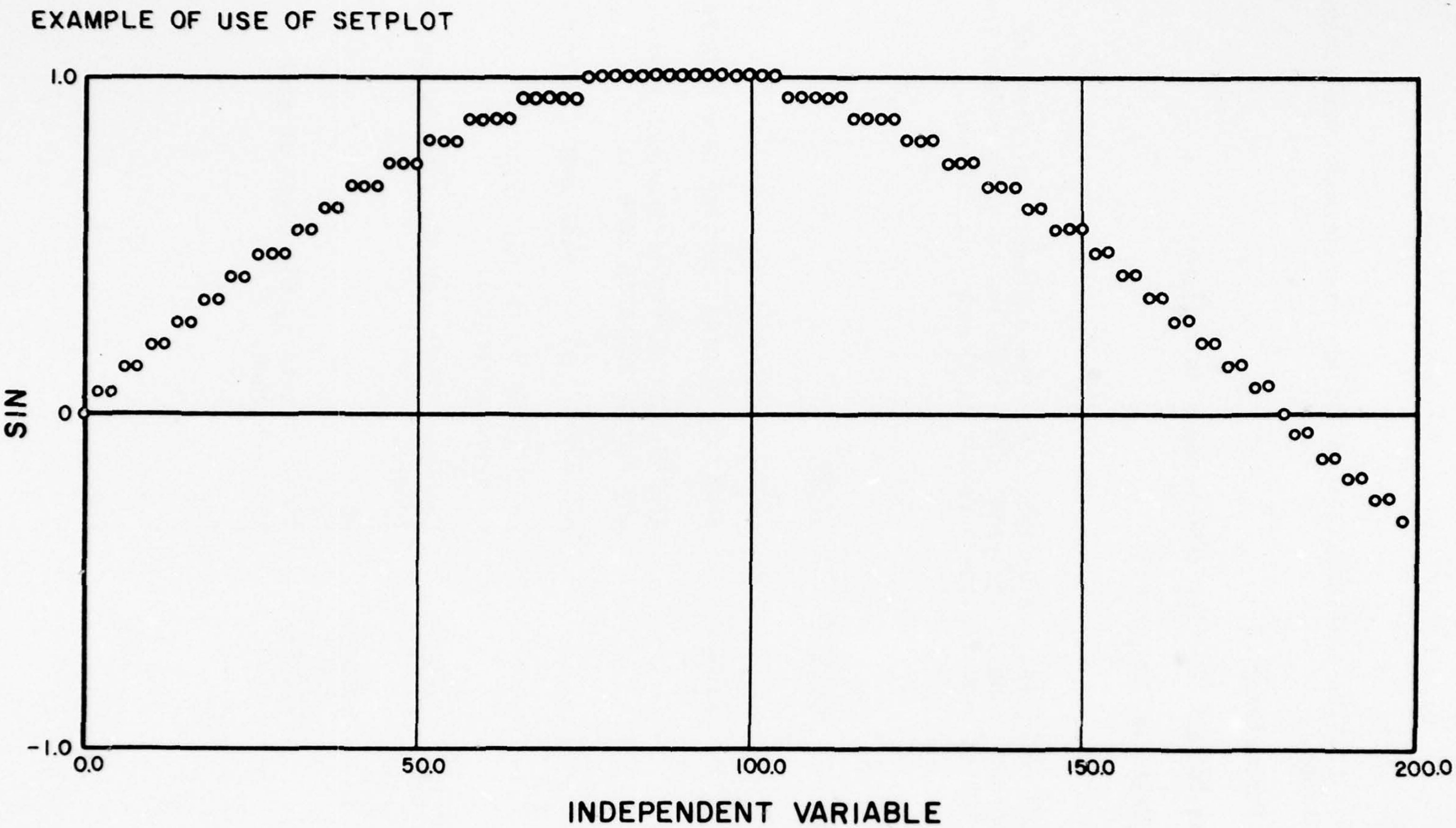


Figure E12. Example of the SETPLOT output.

ZONE

Purpose

This routine reinitializes variables for approach zone earthwork calculations.

Formal Parameters

The header card for ZONE appears as follows:

SUBROUTINE ZONE(KAPR).

Description

ZONE reinitializes variables for the earthwork calculations. As each approach zone is analyzed, ZONE is called to place parameters into the variables used for the pavement earthwork calculations.

Variables

Variable	Location	Usage
ALFWID		T.V.
APREND(9,3)	/ZONES/	Array containing approach zone information: APREND(I,1) is the north-south coordinate of the end of approach zone I. APREND(I,2) is the east-west coordinate. APREND(I,3) is the elevation (ft) of the end of approach zone I.
APRSTR(9,3)	/ZONES/	Same as APREND, for the start of approach zone I.
APTOT	/ZONES/	NA
APWID(9)	/ZONES/	Array containing the width of each approach zone.
A1		T.V.
A2		T.V.
B1		T.V.

Variable	Location	Usage
B2		T.V.
COSA		Cosine of the angle between the north-south line and the terrain data centerline.
COSPGL	/ /	Cosine of the angle between the terrain data centerline and the profile grade line.
CUTCOST	/ /	NA
CUTNET	/ /	NA
CUTPRCE	/TSV/	NA
ECOST	/ /	NA
ELIMHI	/ /	NA
ELIMLO	/ /	NA
ERCOST	/TSV/	NA
FILCOST	/ /	NA
FILLNET	/ /	NA
FILPRCE	/TSV/	NA
HYP		Length of the terrain data centerline (ft).
HYPGL		Length of the profile grade line (ft).
IDO		T.V.
IEXTRAP	/ /	NA
IROW	/ /	NA
KAPR	FP	Number of the approach zone being considered.
NAPR	/ZONES/	NA
NPGL	/ /	Number of profile grade line break points, equal to zero for approach zones.
NTMP	/ /	Number of points defining the template.
PGL(20,2)	/ /	NA

Variable	Location	Usage
PSTEP	/TSV/	Length of the prism (distance along the profile grade line between end area calculations) for the volume calculations (ft).
RELAREA	/ /	Relative area of the template, equal to zero in approach zones.
RUNE(3)	/ /	Array containing profile grade line information: RUNE(1) is the ordinate of the end of the line, first relative to north-south, and finally, relative to the terrain data centerline; RUNE(2) is the abscissa of the end of the line, first relative to east-west, and finally, relative to the terrain data centerline; RUNE(3) is the elevation of this point.
RUNS(3)	/ /	Same as RUNE, but for the beginning of the profile grade line.
SEGBEG	/ /	Distance (ft) from the start of the profile grade line at which earthwork calculations start.
SEGEND	/ /	Same as SEGBEG, but for the end of the calculations.
SINA		Same as COSA, sine of the angle.
SINPGL	/ /	Same as COSPGL, sine of the angle.
SPSTEP	/ /	NA
TER(50,40,2)	/ /	NA
THCK	/TSV/	NA
TLSTART(2)	/ /	TLSTART(1) is the north-south coordinate of the terrain data centerline; TLSTART(2) is the east-west coordinate.
TLSTOP(2)	/ /	Same as TLSTART, but for the end of the terrain data centerline.
TMP(20,2)	/ /	Array containing the coordinates defining the template: TMP(I,1) is the distance from the profile grade line to the Ith template point, positive if right, negative if left (looking upstation); TMP(I,2) is the elevation of this point relative to the elevation of the profile grade line.

Variable	Location	Usage
WHERE(50)	/ /	NA
ZONSTEP(9)	/ZONES/	Length (ft) of the prism for volume calculations for each approach zone.

Common Blocks

The common blocks for ZONE are TSV, ZONES, and blank common.

Tapes

None.

Traceback

ZONE is called by EARTH and calls SQRT (CDC Library) and the inline function ABS.

Illustrations

None.

References

None.

PRICE

Purpose

This routine prints a summary of earthwork costs for the zero thickness pavement used in the original earthwork analysis.

Formal Parameters

The header card for PRICE appears as follows:

SUBROUTINE PRICE.

Description

The volumes of cut and fill are multiplied by their respective unit costs. The cost of approach zone work is added to these costs to obtain a total earthwork cost. The results are written to the user on TAPE4.

Variables

Variable	Location	Usage
APREND(9,3)	/ZONES/	NA
APRSTR(9,3)	/ZONES/	NA
APTOT	/ZONES/	Total cost of approach zone earthwork.
APWID(9)	/ZONES/	NA
COSPGL	/ /	NA
CUTCOST	/ /	Cost of cut.
CUTNET	/ /	Volume of cut, cu yd.
CUTPRCE	/TSV/	Cost/cu yd for cut.
ECOST	/ /	Total cost of earthwork.
ELIMHI	/ /	NA
ELIMLO	/ /	NA
ERCOST	/TSV/	NA
FILCOST	/ /	Cost of fill.
FILLNET	/ /	Volume of fill, cu yd.

Variable	Location	Usage
FILPRCE	/TSV/	Cost/cu yd for fill.
IEXTRAP	/ /	NA
IND	/TMPL/	NA
IROW	/ /	NA
JACK	/TMPL/	Design scheme number.
NAPR	/ZONES/	NA
NPGL	/ /	NA
NTMP	/ /	NA
PGL(20,2)	/ /	NA
PSTEP	/TSV/	NA
RELAREA	/ /	NA
RUNE(3)	/ /	NA
RUNS(3)	/ /	NA
SEGBEG	/ /	NA
SEGEND	/ /	NA
SINPGL	/ /	NA
SPSTEP	/ /	NA
SWID	/TMPL/	NA
TER(50,40,2)	/ /	NA
THCK	/TSV/	Pavement thickness.
TLSTART(2)	/ /	NA
TLSTOP(2)	/ /	NA
TMP(20,2)	/ /	NA
TWOCL	/TMPL/	NA

Variable	Location	Usage
WHERE(50)	/ /	NA
ZONSTEP(9)	/ZONES/	NA

Common Blocks

The common blocks in PRICE are TSV, TMPL, ZONES and blank common.

Tapes

The tape used in PRICE is:

TAPE4--contains the earthwork zero thickness summary.

Traceback

PRICE is called by EARTH and calls the inline function ABS.

Illustrations

None.

References

None.

ZPRICE

Purpose

This routine calculates the earthwork volume and cost for the approach zones.

Formal Parameters

The header card for ZPRICE appears as follows:

SUBROUTINE ZPRICE.

Description

For each approach zone, the end areas are read, the volume calculated, the cut volume saved, and a cost summary printed. After all the approach zones are analyzed, the total cost of all approach zones is printed to the user. The average end area method is used for the volume calculations.

Variables

Variable	Location	Usage
APCOST		Cost for one approach zone.
APREND(9,3)	/ZONES/	NA
APRSTR(9,3)	/ZONES/	NA
APTOT	/ZONES/	Total cost for all approach zones.
APVOL		Volume (cu yd) of cut.
APWID(9)	/ZONES/	NA
ARZN1		End area (sq yd) used for volume calculations (see Figure E2).
ARZN2		End area (sq yd) adjacent to ARZN1.
CUTPRCE	/TSV/	Cost/cu yd for cut.
ERCOST	/TSV/	NA
FILPRCE	/TSV/	NA

Variable	Location	Usage
IFL		Index for end-of-file: zero: no end-of-file encountered nonzero: end-of-file encountered.
IREAD		T.V.
NAPR	/ZONES/	Number of approach zones.
PSTEP	/TSV/	NA
STEP		Length of the prism (ft) for volume calculations.
THCK	/TSV/	NA
VL		Volume (cu yd) between two end areas--negative if cut, positive if fill.
ZONSTEP(9)	/ZONES/	Length (ft) of the prism for volume calculations for each approach zone.

Common Blocks

The common blocks in ZPRICE are TSV and ZONES.

Tapes

The tapes used by ZPRICE are:

TAPE3--contains the end areas for each approach zone, with an end-of-file mark between each set of approach zone data.

TAPE4--writes the approach zone summaries to the user.

Traceback

ZPRICE is called by EARTH and calls EOF anad the inline function ABS.

Illustrations

None.

References

None.

APPENDIX F:

OVERLAY (5,0)

OVERLAY (5,0) simulates Corps of Engineers' criteria for designing pavements for frost conditions (as contained in TM 5-818-2). It was conceived as a stand-alone program which was subsequently integrated into LIFE2 in its entirety. The following routines are contained within overlay (5,0):

Program FROST
Subroutines FREEZE, SUBPEN, RTN25, PURIFY, RSUBG, OUTA, OUTB, OUTC and
Functions DINDEX, and FLXPET.

Output from OVERLAY (5,0) contains three design analyses for frost protection: complete protection, limited subgrade frost penetration, and reduced subgrade strength. Structural layer thicknesses required for frost protection by each method are computed and the applicability of the method is determined. All information is eventually printed with the program results. The final pavement design thicknesses may differ from those computed in this overlay due to overriding traffic or material criteria.

FROST

Purpose

This program functions as the driver in OVERLAY (5,0). It reads the input into COMMON and calls the subroutines required to perform calculations and produce reports.

Formal Parameters

Since FROST has no formal parameters, the header card would be:

PROGRAM FROST

Description

Program FROST initializes the error index array, KWITCHES, to zero. It then reads the fixed format data card for FROST. If no data is found in the first field, then the overlay is terminated. If data is found, default values are loaded and the input is checked for errors by PURIFY. The input data is printed by OUTA. If errors have been found, as indicated by KWITCHES, error messages are printed by OUTB. Subroutine FREEZE is called to do FROST analysis and the results are printed by OUTC.

Variable

Variable	Location	Usage
AMINOR	/KARD/	Code indicating whether pavement is of minor classification. X=Minor Classification Blank=Not Minor Classification
AXK	/LCY/	NA
BMOIST	/KARD/	Water content (in percent) of the base course material. Must be within the following ranges dependent upon the dry unit weight of the material (DRYWT): Dry Unit Wt.(PCF) — Moisture Content (%) 100 — 5-20 100-115 — 5-15 116-134 — 5- 7 135 — 2- 7 136-150 — 2- 5
CBR8	/KARD/	Base course CBR index; when 'X', base CBR=80.
CBR10	/KARD/	Base course CBR index; when 'X', base CBR=100.
COMPF	/BLOCKB/	NA
COMPR	/BLOCKB/	NA
COMS(4)	/KARD/	Character array for user supplied comments.
DESIGN	/KARD/	Design load in pounds.
DFI	/KARD/	Design Freezing Index in degree days.
DRYWT	/KARD/	Dry unit weight (pcf) of the base course material; allowable values dependent on moisture content (see BMOIST).
FAC	/LCY/	NA

Variable	Location	Usage
FCOMPF	/BLOCKB/	NA
FCOMPR	/BLOCKB/	NA
FLEXPT	/KARD/	Flexible pavement thickness; currently defaulted to 6 in. (152.4 mm).
FLSF	/BLOCKB/	NA
FLSR	/BLOCKB/	NA
FRSUBF	/BLOCKB/	NA
FRSUBR	/BLOCKB/	NA
I		TV
ICONFIG	/KARD/	Single digit numerical code (1-8) to describe the Design Load Configuration. Codes are: 1=Single Wheel--100 sq in. (645 cm^2) contact area. 2=Twin Assembly Tricycle Gear, 20-in. (508 mm) spacing, 100 sq in. (645 cm^2) contact area for each wheel. 3=Twin Assembly Tricycle Gear, 37-in. (940 mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 4=Single Tandem Assembly Tricycle Gear, 60-in. (1524 mm) spacing, 400 sq in. (2580 cm^2) contact area for each wheel. 5=Twin Tandem Assembly Tricycle Gear, 31 x 63 in. (787 x 1600 mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 6=Twin Assembly Tricycle Gear, 37-in. (940 mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 7=Twin-Twin Assembly Bicycle Gear, 37 x 62 x 37 in. (940 mm to 1575 x 940)

Variable	Location	Usage
		spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 8=Road Load.
IFGRP	/KARD/	Soil classification code to describe increasing frost susceptibility on scale of one to four. CODE FROST GROUP 1 = F1 2 = F2 3 = F3 4 = F4.
IFLEXNA	/BLOCKD/	NA
IIPAVT	/BLOCKC/	NA
IPAVT	/KARD/	Indicates pavement type (Related to IREST): 1 = Flexible 2 = Rigid 3 = Both.
IREST	/RESTR/	Design Restriction 1 - None 2 - Rigid 3 - Flexible.
IRIGDNA	/BLOCKD/	NA
ISUBCBR	/KARD/	Value of SUBGRADE.CBR.
ISUBHOR	/KARD/	Code indicating horizontal variability of subgrade soil: 1=Uniform 3=Variable 2=Slightly Variable 4=Extremely Variable.
ISWITF	/BLOCKC/	NA
ISWITR	/BLOCKC/	NA
J		TV

Variable	Location	Usage
KWITCHS(20)	/BLOCKA/	Array containing error message switches.
LCIND	/KARD/	NA
LS	/LCY/	NA
MESS(11)	/BLOCKC/	NA
MSGSW1	/BLOCKC/	NA
MSGSW2	/BLOCKC/	NA
MSGSW3	/BLOCKC/	NA
NODQ	/NBLK/	NA
NOGQ	/NBLK/	NA
NOH	/NBLK/	NA
NOSGQ	/NBLK/	NA
NPTQ	/NBLK/	NA
NXQ	/NBLK/	NA
NYQ	/NBLK/	NA
OVR	/KARD/	Blank in this field indicates use of minimum thickness tables for flexible pavement (currently defaulted to a blank).
PRDBTF	/BLOCKB/	NA
PRDBTR	/BLOCKB/	NA
PRFLTF	/BLOCKB/	NA
PRFLTR	/BLOCKB/	NA
PVTFLX	/BLOCKD/	NA
PVTRGD	/BLOCKD/	NA

Variable	Location	Usage
RIGDPT	/KARD/	Rigid pavement thickness (Defaulted to 6 in. [152 mm]).
RSUBF	/BLOCKB/	NA
RSUBR	/BLOCKB/	NA
SLSDBTF	/BLOCKB/	NA
SLSDBTR	/BLOCKB/	NA
SLSPENF	/BLOCKB/	NA
SLSDENR	/BLOCKB/	NA
SMOIST	/KARD/	Subgrade water content (in percent).
SUBMOD	/KARD/	Subgrade modulus (XK) of reaction.
TDFP	/KARD/	Total Depth of Frost Penetration in inches.
TRAFF	/KARD/	Traffic area (alphanumeric): for airfields, the traffic area (A-E), and for roads, the Design Index (1-10).
TRY(20)	/LCY/	NA
XCBR	/LCY/	Value of SUBGRADE.CBR
XK	NBLK/	Subgrade modulus.
XSTR	/LCY/	NA
XTRA	/BLOCKB/	NA
YK	/LCY/	NA

Common Blocks

Common blocks used by FROST are BLOCKA, BLOCKB, BLOCKC, BLOCKD, KARD, LCY, NBLK, RESTR.

Tapes

The tape used by FROST is:
TAPE 3--reads the FROST fixed format card.

Traceback

PROGRAM FROST is called by MAIN and calls FREEZE, OUTA, OUTB, OUTC, and PURIFY.

Illustrations

None.

References

None.

FREEZE

Purpose

This subroutine performs the frost analysis computations.

Formal Parameters

Since FREEZE has no formal parameters, the header card appears as:

SUBROUTINE FREEZE

Description

Subroutine FREEZE performs the majority of the frost analysis calculations and directs the remainder of these calculations. Figure F1 illustrates the procedural flow of FREEZE.

Variables

Variable	Location	Usage
A		T.V.
AMINOR	/KARD/	Code indicating whether pavement is of minor classification. X=Minor classification Blank=Not minor classification (See Figure F6, p F-36).
B		T.V.
BMOIST	/KARD/	Base course water content (in percent); allowable values depend on dry unit weight (see DRYWT).
CBR10	/KARD/	Index for base CBR equal to 100.
CBR8	/KARD/	NA
COMPF	/BLOCKB/	Computed result for flexible pavement complete penetration method.
COMPR	/BLOCKB/	Computed result for rigid complete penetration method.

Variable	Location	Usage
COMS(4)	/KARD/	NA
DBT		Design base thickness.
DESIGN	/KARD/	Design load in pounds.
DFI	/KARD/	Design Freezing Index in degree days.
DRYWT	/KARD/	Dry Unit Weight of the base course material. Following are the required ranges:
FCOMPF	/BLOCKB/	Computed filter thickness for flexible complete penetration method.
FCOMPR	/BLOCKB/	Computed filter thickness for rigid complete penetration method.
FLEXPT	/KARD/	Flexible pavement thickness.
FLSF	/BLOCKB/	Computed thickness for flexible limited subgrade penetration method.
FLSR	/BLOCKB/	Computed thickness for rigid limited subgrade penetration method.
FRSUBF	/BLOCKB/	Computed thickness for flexible reduced strength method.
FRSUBR	/BLOCKB/	Computed thickness for rigid reduced strength method.

DRYWT required ranges:

Dry Unit Weight (PCF)	Moisture Content (%)
100	5-20
100-115	5-15
116-134	5- 7
135	2- 7
136-150	2- 5

Variable	Location	Usage
ICONFIG	/KARD/	Single digit numerical code (1-8) to describe the Design Load Configuration. Codes are: 1=Single Wheel--100 sq in. (645 cm^2) contact area. 2=Twin Assembly Tricycle Gear, 20 in. (508 mm) spacing, 100 sq in. (645 cm^2) contact area for each wheel. 3=Twin Assembly Tricycle Gear, 37 in. (940 mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 4=Single Tandem Assembly Tricycle Gear, 60 in. (1524 mm) spacing, 400 sq in. (2580 cm^2) contact area for each wheel. 5=Twin Tandem Assembly Tricycle Gear, 31 x 63 in. (787 x 1600 mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 6=Twin Assembly Tricycle Gear, 37-in. (940 mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 7=Twin-Twin Assembly Bicycle Gear, 37 x 62 x 37 in. (940 x 1575 x 940 mm) spacing, 267 sq in. (1722 cm^2)tact area for each wheel. 8=Road Load.
IFGRP	/KARD/	Soil classification code to describe increasing frost susceptibility on a scale of one to four (See Figure F3, p F-19): CODE FROST GROUP 1 = F1 2 = F2 3 = F3 4 = F4.
IFLAG	/FLAG/	Flag to indicate pavement type: 1=flexible 2=rigid.

Variable	Location	Usage
IFLEXNA	/BLOCKD/	Flag to print not applicable indication for flexible methods.
IIPAVT	/BLOCKC/	Indicates pavement type 1=Flexible 2=Rigid 3=Both.
IPAVT	/KARD/	Indicates pavement type 1=Flexible 2=Rigid 3=Both.
IRIGDNA	/BLOCKD/	Flag to print not applicable indication for rigid methods.
ISUBCBR	/KARD/	Value of SUBGRADE.CBR.
ISUBHOR	/KARD/	Code indicating horizontal variability of subgrade soil: 1=Uniform 3=Variable 2=Slightly Variable 4=Extremely Variable.
ISWITF	/BLOCKC/	Flexible preferred choice switch.
ISWITR	/BLOCKC/	Rigid preferred choice switch.
ISWITX	/BLOCKE/	Switch for suppression of reduction messages.
ITEST		Numeric value assigned to TRAFF; positive if TRAFF is numeric, negative if TRAFF is alphabetic.
K		T.V.
KFLAG		Index designating ROAD. LOAD when KFLAG=1
KGO		T.V.

Variable	Location	Usage
MESS(11)	/BLOCKC/	Array equivalenced to the values of MSG1 through MSG11.
MG01		Temporary switch for Method 1 - complete penetration.
MG02		Temporary switch for Method 1 - complete penetration.
MG03		Temporary switch for Method 1 - complete penetration.
MSGSW1	/BLOCKC/	Switch to print "APPROVAL" message for Method 1 - complete penetration. See OUTC.
MESGSW2	/BLOCKC/	Switch to print "APPROVAL" message for Method 2 - limited subgrade frost penetration. See OUTC.
MSGSW3	/BLOCKC/	Switch to print "APPROVAL" message for Method 3 - reduced subgrade strength. See OUTC.
MSG01		Temporary Switch.
MSG02		Temporary Switch.
MSG1	/BLOCKC/	Switch used for printing messages.
MSG10	/BLOCKC/	Switch used for printing messages.
MSG11	/BLOCKC/	Switch used for printing messages.
MSG2	/BLOCKC/	Switch used for printing messages.
MSG3	/BLOCKC/	Switch used for printing messages.

Variable	Location	Usage
MSG4	/BLOCKC/	Switch used for printing messages.
MSG5	/BLOCKC/	Switch used for printing messages.
MSG6	/BLOCKC/	Switch used for printing messages.
MSG7	/BLOCKC/	Switch used for printing messages.
MSG8	/BLOCK/	Switch used for printing messages.
MSG9	/BLOCK/	Switch used for printing messages.
OVR	/KARD/	Defaulted to blank to specify use of flexible minimum thickness tables.
PRDBTF	/BLOCKB/	Flexible preferred method result.
PRDBTR	/BLOCKB/	Rigid preferred method result.
PRFLTF	/BLOCKB/	Flexible preferred method filter result.
PRFLTR	/BLOCKB/	Rigid preferred method filter result.
PVTFLX	/BLOCKD/	Flexible pavement thickness.
PVTRGD	/BLOCKD/	Rigid pavement thickness.
R		T.V.
RA		T.V.
RIGDPT	/KARD/	Rigid pavement thickness.
RSUBF	/BLOCKB/	Flexible reduced strength method result.

Variable	Location	Usage
RSUBR	/BLOCKB/	Rigid reduced strength method result.
RX		Total rigid pavement thickness for reduced strength method.
S		T.V.
SAVA		Used to calculate SVTDFP.
SAVB		Used to calculate SVTDFP.
SFP		Subgrade frost penetration depth.
SLSDBTF	/BLOCKB/	Flexible limited subgrade penetration method result.
SLSDBTR	/BLOCKB/	Rigid limited subgrade penetration method result.
SLSPENF	/BLOCKB/	Frost penetration for flexible limited subgrade penetration method.
SLSPENR	/BLOCKB/	Frost penetration for rigid limited subgrade penetration method.
SMOIST	/KARD/	Water content of subgrade (in percent).
SUBMOD	/KARD/	Subgrade modulus.
SVTDFP		Total depth of frost penetration.
T		Total depth of base plus pavement in flexible reduced strength method.
TDFP	/KARD/	Total depth of frost penetration in inches.
TRAFF	/KARD/	Traffic area code (alpha-numeric); for airfields, the traffic area (A-E), and for roads, the Design Index (1-10).

Variable	Location	Usage
X		Total design thickness.
XFLXPVT		Value of input pavement thickness.
XTRA	/BLOCKB/	Message switch for comparing flexible input to flexible table.
Y		T.V.
YY		T.V.
Y1		T.V.
Y2		T.V.

Common Blocks

The common blocks used by FREEZE are: KARD, FLAG, BLOCKB, BLOCKC, BLOCKD, BLOCKE.

Tapes

None.

Traceback

Subroutine FREEZE is called by FROST and calls FLXPET, RSUBGR, RTN25 and SUBPEN, and the inline function SHIFT.

Illustrations

Figure F1 is a descriptive flowchart of FREEZE.

Figure F2 is an example of the charts used to relate air freezing index and frost penetration depth (Figures 9-11; TM 5-818-2).

Figure F3 shows the relationship between gear load, frost group, and airfield flexible pavement and base thickness for reduced subgrade strength method. This relationship varies with the time configuration (Figures 13, 14, 15, 15a, 16, 17, 18 of TM 5-818-2).

Figure F4 relates subgrade modulus, frost group, and rigid pavement base for needed subgrade, strength method (Figure 20 of TM 5-818-2).

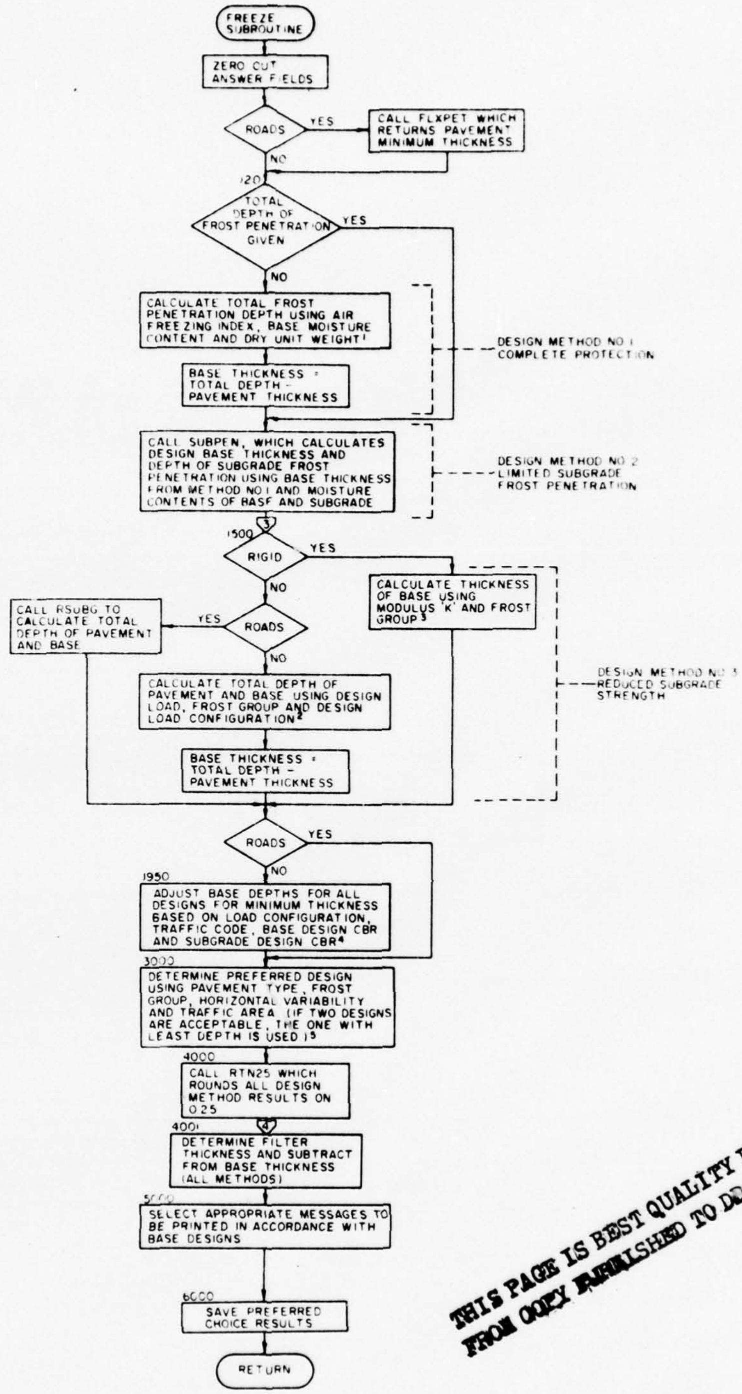
Table F1 is the minimum airfield pavement and base thickness (Table II, TM5-824-2).

Table F2 summarizes the conditions affecting the frost protective method selection (Table 2, TM5-818-2).

References

Pavement Design for Frost Conditions, TM 5-818-2 (Department of the Army, July 1965).

Airfield Flexible Pavements - Air Force, TM 5-824-2 (Department of the Air Force, 7 February 1969).



NOTE 1: SEE FIGURE F-2
NOTE 2: SEE FIGURE F-3
NOTE 3: SEE FIGURE F-4
NOTE 4: SEE FIGURE F-5
NOTE 5: SEE FIGURE F-6

Figure F1. Subroutine FREEZE flowchart.

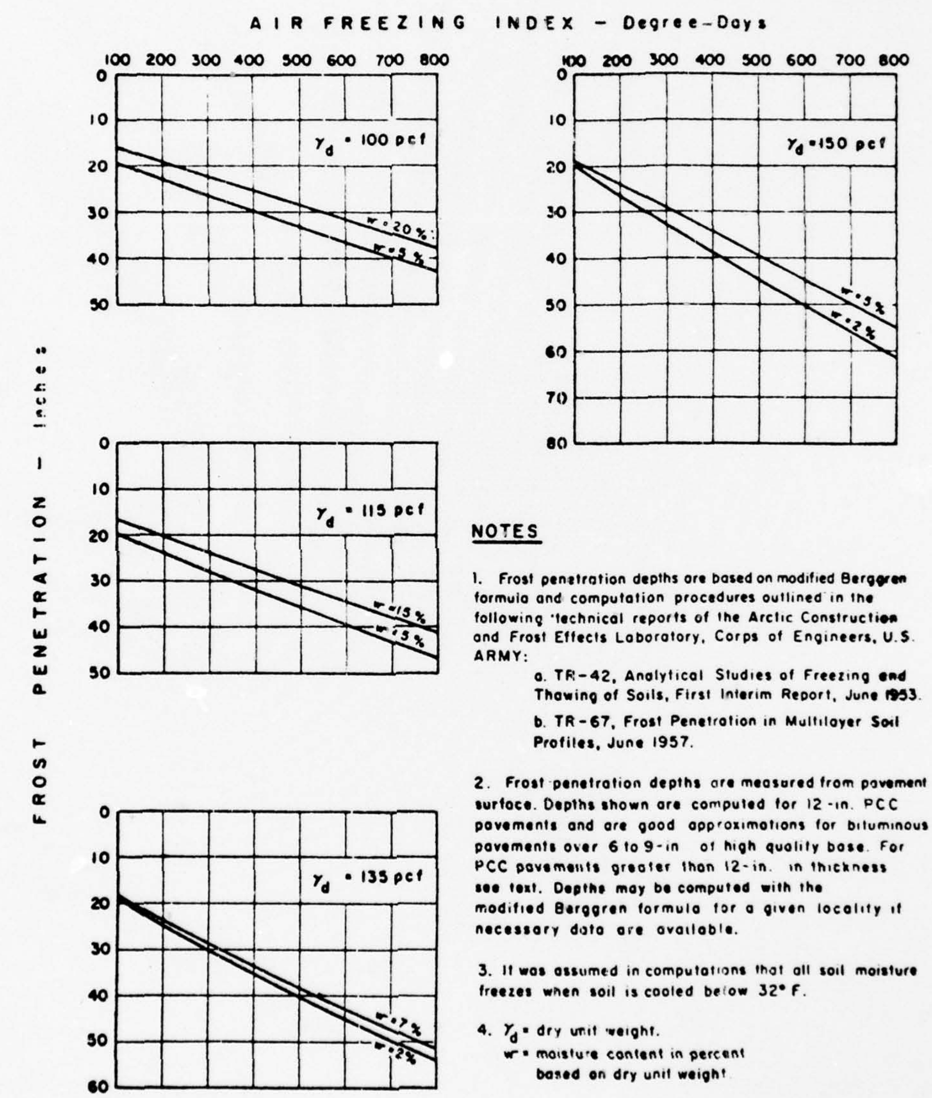
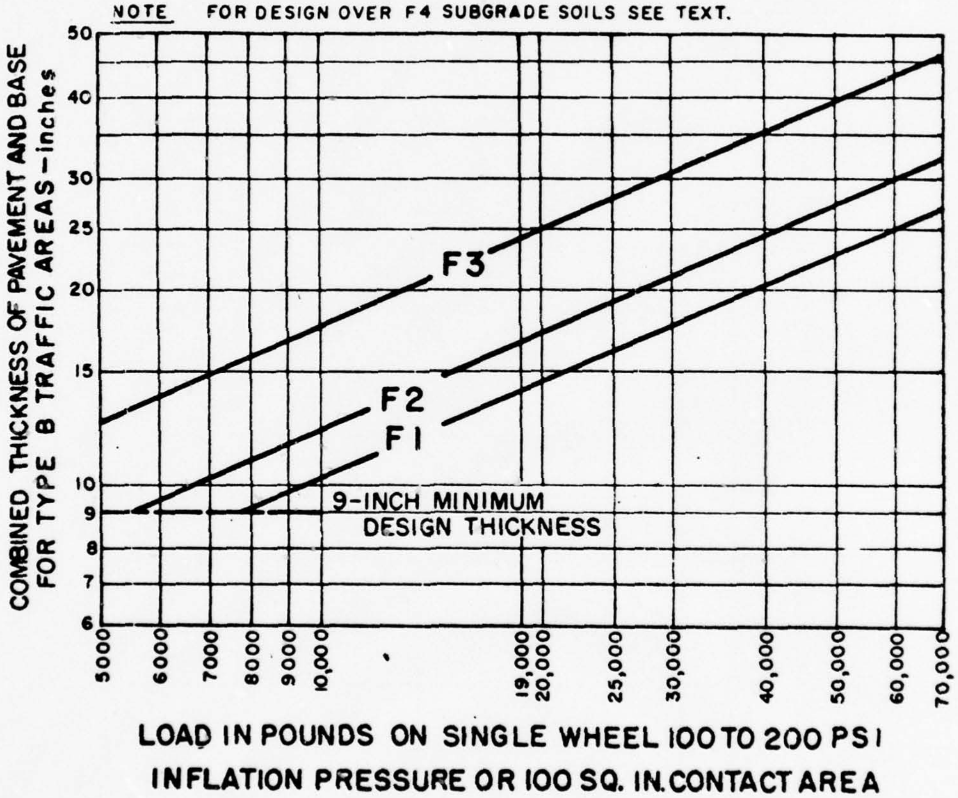


Figure F2. Relationships between air freezing index and frost penetration into granular, nonfrost-susceptible soil beneath pavements kept free of snow and ice for freezing indexes below 800.

GROUP	DESCRIPTION
F1	GRAVELLY SOILS CONTAINING BETWEEN 3 AND 10 PERCENT FINER THAN 0.02 mm BY WEIGHT.
F2	(a) GRAVELLY SOILS CONTAINING BETWEEN 10 AND 20 PERCENT FINER THAN 0.02 mm BY WEIGHT (b) SANDS CONTAINING BETWEEN 3 AND 15 PERCENT FINER THAN 0.02 mm BY WEIGHT.
F3	(a) GRAVELLY SOILS CONTAINING MORE THAN 20 PERCENT FINER THAN 0.02 mm BY WEIGHT (b) SANDS, EXCEPT VERY FINE SILTY SANDS, CONTAINING MORE THAN 15 PERCENT FINER THAN 0.02 mm BY WEIGHT (c) CLAYS WITH PLASTICITY INDEXES OF MORE THAN 12.
F4	(a) ALL SILTS (b) VERY FINE SILTY SANDS CONTAINING MORE THAN 15 PERCENT FINER THAN 0.02 mm BY WEIGHT (c) CLAYS WITH PLASTICITY INDEXES OF LESS THAN 12 (d) VARVED CLAYS AND OTHER FINE-GRAINED BANDED SEDIMENTS.

NOTE FOR DESIGN OVER F4 SUBGRADE SOILS SEE TEXT.



FOR TYPE C TRAFFIC AREAS REDUCE THE DESIGN ASSEMBLY LOAD BY 25 PERCENT

Figure F3. Frost condition reduced subgrade strength design curves for flexible pavements.

GROUP	DESCRIPTION
F1	GRAVELLY SOILS CONTAINING BETWEEN 3 AND 10 PERCENT FINER THAN 0.02 mm BY WEIGHT
F2	(a) GRAVELLY SOILS CONTAINING BETWEEN 10 AND 20 PERCENT FINER THAN 0.02 mm BY WEIGHT (b) SANDS CONTAINING BETWEEN 3 AND 15 PERCENT FINER THAN 0.02 mm BY WEIGHT
F3	(a) GRAVELLY SOILS CONTAINING MORE THAN 20 PERCENT FINER THAN 0.02 mm BY WEIGHT (b) SANDS, EXCEPT VERY FINE SILTY SANDS, CONTAINING MORE THAN 15 PERCENT FINER THAN 0.02 mm BY WEIGHT (c) CLAYS WITH PLASTICITY INDEXES OF MORE THAN 12
F4	(a) ALL SILTS (b) VERY FINE SILTY SANDS CONTAINING MORE THAN 15 PERCENT FINER THAN 0.02 mm BY WEIGHT (c) CLAYS WITH PLASTICITY INDEXES OF LESS THAN 12 (d) VARVED CLAYS AND OTHER FINE-GRAINED BANDED SEDIMENTS.

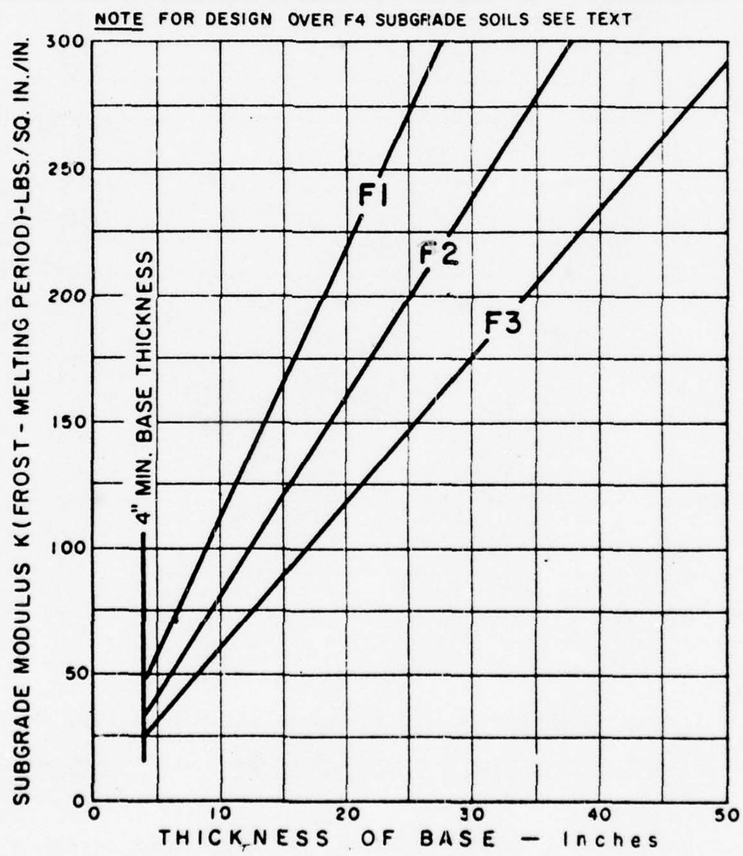


Figure F4. Frost condition reduced subgrade strength design subgrade modulus curves for rigid airfield and highway pavements.

Table F1

Pavement and Base Thickness Design Criteria

Heavy-Load Design

Twin-twin assembly, bicycle; spacing, 37-62-37 in. center-to-center; contact area, 267 sq. in. each wheel

	Minimum thickness, in.(1)					
	100-CBR base			80-CBR base(2)		
Traffic area	Pavement	Base	Total	Pavement	Base	Total
A	5	10	15	6	9	15
B	4	9	13	5	8	13
C	4	9	13	5	8	13
D	3	6	9	3	6	9
Access aprons(3)	3	6	9	3	6	9
Shoulders	2	6	8	2	6	8

Medium-Load Design

Twin assembly, tricycle; spacing 37 in. center-to-center; contact area, 267 sq. in. each wheel

	Minimum thickness, in.(1)					
	100-CBR base			80-CBR base(4)		
Traffic area	Pavement	Base	Total	Pavement	Base	Total
A	4	6	10	5	6	11
B	3	6	9	4	6	10
C	3	6	9	4	6	10
Access aprons	3	6	9	3	6	9

Light-Load Design

Single wheel, tricycle; contact area, 100 sq. in.

	Minimum thickness, in.(1)					
	100-CBR base			80-CBR base(5)		
Traffic area	Pavement	Base	Total	Pavement	Base	Total
B	3	6	9	4	6	10
C	3	6	9	3	6	9
Access aprons	3	6	9	4	6	10

102367E

(1) These minimum thicknesses apply when layer directly under the base course has a design CBR of 50; when the underlying layer has a design CBR of 80, the minimum thickness of base course shall be 6 in.

(2) Restricted to Florida limerock except that stabilized aggregate will be permitted in type D traffic areas.

(3) Applicable in other than cold climates (see TM 5-824-1/AFM 88-6, Chap. 1).

(4) Florida limerock or stabilized aggregate permitted in types B and C traffic areas.

(5) Florida limerock or stabilized aggregate permitted.

Table F2

Summary of Methods for Design of Airfield Pavements for Frost Conditions

(From *Pavement Design for Frost Conditions*, TM 5-818-2 [Department of the Army], July 1965.)

<table>
<tr><th rowspan="2">Design Method

(1)</th><th colspan="4">Horizontal Variability of Subgrade Soil and Moisture Conditions</th></tr>
<tr><th>Uniform
Variations affecting heave potential virtually undetectible by ordinary methods of investigation. Negligible differential frost heave and thaw settlement may be anticipated under reduced subgrade strength design.

(2)</th><th>Slightly Variable
Small variations of subgrade conditions apparent by ordinary methods of investigation.

(3)</th><th>Variable
Subgrade conditions moderately variable. Widespread cracking of rigid pavements and appreciable surface deformation would be expected if reduced subgrade strength design method were used.

(4)</th><th>Extremely Variable
Very large, frequent, and abrupt changes in subgrade frost heave potential not permitting use of transition sections.

(5)</th></tr>
<tr><td>Complete Protection</td><td></td><td></td><td></td><td>Applicable only under exceptionally adverse conditions for F3 and F4 subgrades.</td></tr>
<tr><td>Limited Subgrade Frost Penetration
(i)
(ii)
(iii)</td><td colspan="3">Required for flexible and rigid pavements:
(1) Over F4 subgrade soils (except as noted in col. (4) below).
(2) Over other frost-susceptible subgrade soils when:
(a) Cracking of rigid pavements or unacceptable pavement roughness caused by nonuniform frost heave may be expected with lesser design thickness, or
(b) Limited subgrade frost penetration design requires less combined thickness or is otherwise more economical than reduced subgrade strength design.</td><td></td></tr>
<tr><td>Reduced Subgrade Strength
(i)
(ii)
(iii)</td><td>Applicable for flexible and rigid pavements over F1 through F3 subgrades when objectionable differential heave or cracking will not occur.
(iv)</td><td>Applicable for flexible pavements over F1 through F3 subgrades when objectional differential heave or cracking will not occur.</td><td>Applicable for flexible pavements over F1 through F4 subgrades when pavements are minor, slow speed, and noncritical and heave can be tolerated, except not to be used for F4 subgrade under adverse moisture conditions.</td><td></td></tr>
</table>

(i) Transition sections required at any substantial and abrupt changes in subgrade frost heave potential which would produce unacceptable pavement roughness and cracking.

(ii) When indicated combined thickness exceeds 72 in., consider alternatives: (1) limiting total thickness to 72 in., and, in rigid-type pavements, using steel reinforcement, (2) reduced slab dimensions, or (3) base of higher moisture retention. OCE approval required for use of alternatives or thickness over 72 in.

(iii) Thickness intermediate between reduced subgrade strength and limited subgrade frost penetration design values may be adopted when justification based on field experience or special conditions of the design is provided.

(iv) Special provision for rigid pavements over uniform subgrades: Instead of base equal to slab thickness, 4-in. minimum base is allowed over F1, F2, F3 subgrades when: (1) design freezing index is 1000 or, (2) subgrade is susceptible to pumping and water table is below 10 ft; however, base drainage criteria must be met.

NOTE: Design of highway pavements should be based generally on the reduced subgrade strength design method, with additional thickness (based on local field data and experience) used where necessary to keep pavement heave and cracking within tolerable amounts. Where such added thicknesses are used for highways they should not exceed values obtained by the limited subgrade frost penetration design method. Thickness reduction up to 10% may also be allowed on substantial highway fills when justified by field data and experience.

SUBPEN

Purpose

This subroutine performs calculations for the limited subgrade frost penetration method.

Formal Parameters

The header card for SUBPEN is as follows:

SUBROUTINE SUBPEN(T,U,V).

Description

Subroutine SUBPEN models Figure F5 (Figure 12 of TM 5-813-2). Given the base thickness for no subgrade frost penetration and the ratio of base-subgrade moisture contents, the subroutine determines the design base thickness and resultant subgrade frost penetration.

Variables

Variable	Location	Usage
A		TV
AMINOR	/KARD/	NA
BMOIST	/KARD/	Percentage of water content of the Base Course Material.
CBR10	/KARD/	NA
CBR8	/KARD/	NA
COMS(4)	/KARD/	NA
DESIGN	/KARD/	NA
DFI	/KARD/	NA
DRYWT	/KARD/	NA
FLEXPT	/KARD/	Flexible pavement thickness.
ICONFIG	/KARD/	NA
IFGRP	/KARD/	NA

Variable	Location	Usage
IFLAG	/KARD/	Flag to indicate pavement type: 1=flexible 2=rigid.
IIPAVT	/BLOCKC/	NA
IPAVT	/KARD/	NA
ISUBCBR	/KARD/	NA
ISUBHOR	/KARD/	NA
ISWITF	/BLOCKC/	NA
ISWITR	/BLOCKC/	NA
MESS(11)	/BLOCKC/	NA
MSGSW1	/BLOCKC/	NA
MSGSW2	/BLOCKC/	Switch to print "APPROVAL" message for Method 2 - Limited Subgrade Frost Penetration. See OUTC.
MSGSW3	/BLOCKC/	NA
OVR	/KARD/	NA
R		Ratio of percentage of water content of the subgrade material to the percentage of water content of the base course material.
RIGDPT	/KARD/	Rigid pavement thickness.
SMOIST	/KARD/	Percentage of water content of the subgrade material.
SUBMOD	/KARD/	NA
S1		T.V.
S2		T.V.
T	FP	Flexible complete penetration method result.

Variable	Location	Usage
TDFP	/KARD/	NA
TRAFF	/KARD/	NA
U	FP	Design base thickness.
V	FP	Subgrade frost penetration.
X		Combined thickness of pavement and nonfrost-susceptible base for zero frost penetration into subgrade.

Common Blocks

Common blocks used in SUBPEN are: BLOCKC, KARD, FLAG.

Tapes

None.

Traceback

Subroutine SUBPEN is called by FREEZE.

Illustrations

Figure F5 presents the curves used for determining the design base thickness for the limited subgrade frost penetration method.

References

Pavement Design for Frost Conditions, TM 5-818-2 (Department of the Army, July 1965).

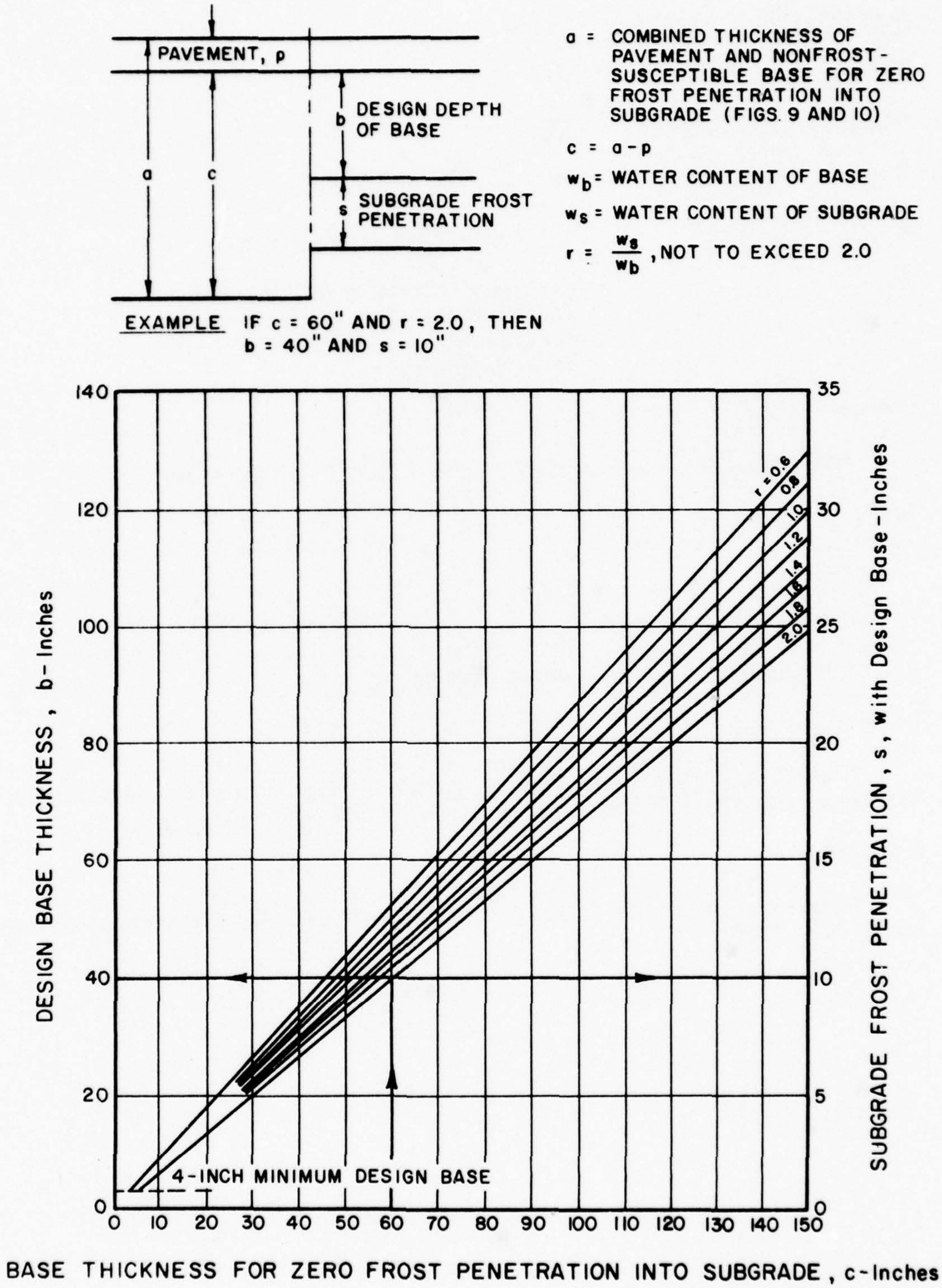


Figure F5. Design depth of nonfrost-susceptible base for limited subgrade frost penetration. (From Figure 12, TM 5-818-2).

RTN25

Purpose

RTN25 is used to round all results in FREEZE on 0.25.

Formal Parameters

The header card for RTN25 appears as follows:

```
SUBROUTINE RTN25(A)
```

Description

The value transferred to RTN25 for rounding (A) has its integer value (IA) subtracted from it. The difference is compared to 0.25. If larger or equal, A becomes IA + 1; if smaller, A becomes IA.

Variables

Variable	Locatio	Usage
A	FP	Value to be rounded
IA		Integer value of A
XY		Difference between real value A and integer value IA.

Common Blocks

None

Tapes

None

Traceback

Subroutine RTN25 is called by FREEZE.

Illustrations

None.

References

None.

PURIFY

Purpose

This subroutine is used to validate the input data for OVERLAY (5,0).

Formal Parameters

The header card for PURIFY is:

SUBROUTINE PURIFY

Description

Subroutine PURIFY checks the input data transferred to OVERLAY (5,0) by common blocks BLOCKA and KARD. Array KWITCHES is used as a switch to indicate errors. If PROGRAM FROST finds an error indication in KWITCHES, OVERLAY (5,0) is terminated after OUTB prints error messages.

Variables

Variable	Location	Usage
AMINOR	/KARD/	Code indicating whether pavement is of minor classification. X=Minor classification Blank=Not minor classification
BMOIST	/KARD/	Percentage of water content of the Base Course Material. See DRYWT for range.
CBR10	/KARD/	Index for base CBR equal to 100.
CBR8	/KARD/	Index for base CBR equal to 80.
COMS(4)	/KARD/	NA
DESIGN	/KARD/	Design load in pounds.
DFI	/KARD/	Design Freezing Index in degree days.

Variable	Location	Usage
DRYWT	/KARD/	Dry Unit Weight of the Base Course Material. The following are the required ranges:
FLEXPT	/KARD/	Flexible pavement thickness.
ICONFIG	/KARD/	Single digit numerical code (1-8) to describe the Design Load Configuration. Codes are:

Dry Unit Weight (PCF)	Moisture Content (%)
100	5-20
100-115	5-15
116-134	5- 7
135	2- 7
136-150	2- 5

1=Single Wheel--100 sq in. (645 cm^2) contact area.

2=Twin Assembly Tricycle Gear, 20-in. (508 mm) spacing, 100 sq in. (645 cm^2) contact area for each wheel.

3=Twin Assembly Tricycle Gear, 37-in. (940 mm) spacing, 267 sq in. (645 cm^2) contact area for each wheel.

4=Single Tandem Assembly Tricycle Gear, 60-in. (1524 mm) spacing, 400 sq in. (2580 cm^2) contact area for each wheel.

5=Twin Tandem Assembly Tricycle Gear, 31 x 63 in. (787 x 1600 mm) spacing, 267 sq in. (645 cm^2) contact area for each wheel.

6=Twin Assembly Tricycle Gear, 37-in. (940 mm) spacing, 267 sq in. (645 cm^2) contact area for each wheel.

7=Twin-Twin Assembly Bicycle Gear, 37 x 62 x 37 in. (940 x 1575 x 940 mm) spacing, 267 sq in. (645 cm^2) contact area for each wheel.

8=Road Load.

Variable	Location	Usage
IFGRP	/KARD/	Soil classification code to describe increasing frost susceptibility on scale of one to four. CODE FROST GROUP 1 = F1 2 = F2 3 = F3 4 = F4.
IPAVT	/KARD/	Indicates pavement type analyzed. 1=Flexible 2=Rigid 3=Both.
ISUBCBR	/KARD/	NA
ISUBHOR	/KARD/	Code indicating Horizontal Variability of subgrade soil: 1=Uniform 3=Variable 2=Slightly Variable 4=Extremely Variable
ITEST		Numeric value assessed to TRAFF; positive if TRAFF is numeric, negative if TRAFF is alphabetic.
KWITA	/BLOCKA/	Error message switch; see OUTB for description of error message.
KWITB	/BLOCKA/	As above.
.	.	.
.	.	.
.	.	.
KWITS	/BLOCKA/	As above
KWITT	/BLOCKA/	As above
KWITCHES	/BLOCKA/	Array containing error message switches.

Variable	Location	Usage
OVR	/KARD/	Defaulted to blank to specify use of minimum thickness tables in flexible design.
RIGDPT	/KARD/	Rigid pavement thickness.
SMOIST	/KARD/	Percentage of water content in subgrade material.
SUBMOD	/KARD/	Subgrade Modules of Reaction (k).
TDFP	/KARD/	Total Depth of Frost Penetration in inches.
TRAFF	/KARD/	Traffic area code (alphanumeric). For airfields, the traffic area (A-E) and for roads, the Design Index (1-10).

Common Blocks

The common blocks used in PURIFY are: BLOCKA, KARD.

Tapes

None.

Traceback

Subroutine PURIFY is called by FROST.

Illustrations

None.

References

None.

RSUBG

Purpose

RSUBG sets up the parameters for frost analysis by the reduced subgrade strength method for flexible highway design.

Formal Parameters

The header card for RSUBG appears as follows:

SUBROUTINE RSUBG (RSUB,IFGRP,DI).

Description

To determine pavement thickness requirements for flexible highways based on the reduced subgrade strength method, RSUBG is called by FREEZE. Appropriate design parameters are selected in RSUBG based on the frost group and design index. These parameters are then sent to FUNCTION DINDEX where the required pavement thickness is computed.

Variables

Variable	Location	Usage
DI	FP	Design Index for the traffic area code. For roads, the Design Index is an integer from 1 through 10.
IFGRP	FP	Soil classification code to describe increasing frost susceptibility on scale of one to four: Code Frost Group 1 = F1 2 = F2 3 = F3 4 = F4.
RSUB	FP	Related to flexible reduced strength method result; total depth of base plus pavement.

Common Blocks

None.

Tapes

RSUBG uses the following tape: TAPE 6 -- writes error messages.

Traceback

Subroutine RSUBG is called by FREEZE, and calls DINDEX.

Illustrations

None.

References

None.

DINDEX

Purpose

DINDEX calculates the design thickness for flexible highway pavements using the reduced subgrade strength method.

Formal Parameters

The header card for DINDEX appears as follows:

FUNCTION DINDEX (X1,X2,Y1,Y2,Y).

Description

DINDEX models Figure F6 to obtain a design thickness for flexible highway pavements based on reduced subgrade strength criteria. The design index and subgrade frost group are defined in RSUBG and sent to DINDEX as input to Figure F6.

Variables

Variable	Location	Usage
DINDEX		Value used as the total depth of base plus pavement for Flexible Reduced Strength method for ROAD.LOAD.
XI	FP	Thickness coordinate for thickness-Design Index curve (lower value).
X2	FP	Thickness coordinate for thickness-Design Index curve (upper value).
Y	FP	Design Index
Y1	FP	Lower value of design index range for thickness-design index curve.
Y2	FP	Upper value of design index range for thickness-design index curve.

Common Blocks

None

Tapes

None

Traceback

DINDEX is called by Subroutine RSUBG.

Illustrations

Figure F6 shows the relationship between design index, frost group, and flexible highway design thickness considering reduced subgrade strength method (Figure 19, TM 5-818-2).

References

Pavement Design for Frost Conditions, TM 5-818-2 (Department of the Army, July 1965).

GROUP	DESCRIPTION
F 1	GRAVELLY SOILS CONTAINING BETWEEN 3 AND 10 PERCENT FINER THAN 0.02mm BY WEIGHT.
F 2	(a) GRAVELLY SOILS CONTAINING BETWEEN 10 AND 20 PERCENT FINER THAN 0.02mm BY WEIGHT. (b) SANDS CONTAINING BETWEEN 3 AND 15 PERCENT FINER THAN 0.02mm BY WEIGHT
F 3	(a) GRAVELLY SOILS CONTAINING MORE THAN 20 PERCENT FINER THAN 0.02mm BY WEIGHT (b) SANDS, EXCEPT VERY FINE SILTY SANDS CONTAINING MORE THAN 15 PERCENT FINER THAN 0.02mm BY WEIGHT. (c) CLAYS WITH PLASTIC INDEXES OF MORE THAN 12.
F 4	(a) ALL SILTS (b) VERY FINE SILTY SANDS CONTAINING MORE THAN 15 PERCENT FINER THAN 0.02mm BY WEIGHT (c) CLAYS WITH PLASTICITY INDEXES OF LESS THAN 12 (d) VARVED CLAYS AND OTHER FINE-GRAINED BANDED SEDIMENTS.

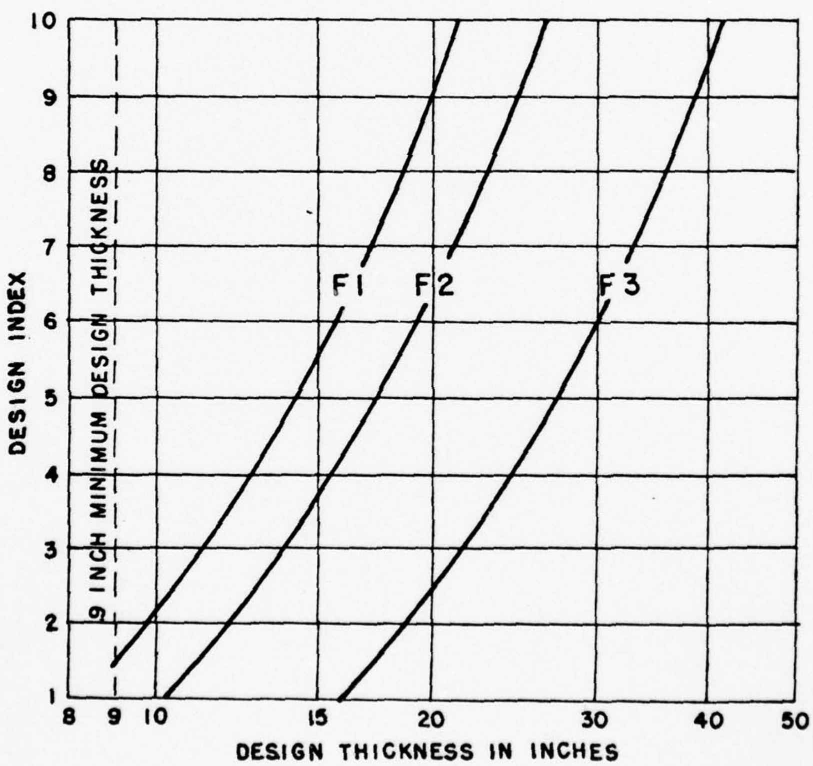


Figure F6. Frost condition reduced subgrade strength design curves for flexible highway pavements. (From Figure 19, TM 5-818-2).

FLXPET

Purpose

FLXPET is a FUNCTION which determines the minimum allowable thickness of flexible pavement and base course for road design.

Formal Parameters

The header card for FLXPET appears as follows:

```
FUNCTION FLXPET(DI,CBR).
```

Description

FLXPET simulates the minimum thickness table given in Table F3 (Table II in TM 5-822-5). Given the design index (DI) and a minimum base course CBR of 100, 80, or 50 (CBR), the function returns the minimum allowable thickness for pavement and base layers for flexible roadway design.

Variables

Variable	Location	Usage
CBR	FP	When CBR=X, CBR value is 100.
DI	FP	Design Index for the traffic area code. For roads, the Design Index is an integer from 1 to 10.
FLXPET		Flexible pavement thickness which is assigned to FLEXPT in subroutine FREEZE.

Common Blocks

None.

Tapes

None.

Traceback

Function FLXPET is called by FREEZE.

Illustrations

Table F3 presents the minimum thickness table for flexible road design (Table II in TM5-822-5).

References

Flexible Pavements for Roads, Streets, Walks, and Open Storage Areas, Table II, (Department of the Army, June 1971).

Table F3

Minimum Thickness of Pavement and Base (Table II, TM 5-818-2)

	Minimum Base Course CBR								
	100			80			50(a)		
Design Index	Pavement in.	Base in.	Total in.	Pavement in.	Base in.	Total in.	Pavement in.	Base in.	Total in.
1	ST(b)-1/2	4	4-1/2(c)	MST(d)-1/2	4	4-1/2(c)	2	4	6
2	MST(d)	4	5(c)	1-1/2	4	5-1/2(c)	2-1/2	4	6-1/2
3	1-1/2	4	5-1/2(c)	1-1/2	4	5-1/2(c)	2-1/2	4	6-1/2
4	1-1/2	4	5-1/2(c)	2	4	6	3	4	7
5	2	4	6	2-1/2	4	6-1/2	3-1/2	4	7-1/2
6	2	4	6-1/2	3	4	7	4	4	8
7	2-1/2	4	6-1/2	3	4	7	4	4	8
8	3	4	7	3-1/2	4	7-1/2	4-1/2	4	8-1/2
9	3	4	7	3-1/2	4	7-1/2	4-1/2	4	8-1/2
10	3-1/2	4	7-1/2	4	4	8	5	4	9

(a) In general 50-CBR base course will only be used for classes E and F roads and streets.
(b) Bituminous surface treatment (spray application).
(c) Minimum total thickness of pavement plus base for classes A through D roads and streets will be 6 in.
(d) Multiple bituminous surface treatment (spray application).

OUTA

Purpose

Subroutine OUTA is used for printing the frost data in the output.

Formal Parameters

The header card for OUTA appears as follows:

SUBROUTINE OUTA(I).

Description

Subroutine OUTA formats each of the frost analysis input variables and places them on tape I for subsequent printing in the output.

Variables

Variable	Location	Usage
AMINOR	/KARD/	Code indicating whether pavement is of minor classification: X=Minor classification Blank=Not minor classification.
BMOIST	/KARD/	Percentage of water content of the Base Course Material. See DRYWT for range.
CBR10	/KARD/	Index for base CBR equal to 100.
CBR8	/KARD/	Index for base CBR equal to 80. "X" indicates that this CBR is to be used in analysis.
COMS(4)	/KARD/	Character array for user-supplied comments.
DESIGN	/KARD/	Design load in pounds.
DFI	/KARD/	Design Freezing Index in degree days.
DRYWT	/KARD/	Dry Unit Weight of the Base Course Material. The following are the required ranges:

Variable	Location	Usage

Dry Unit Weight (PCF)	Moisture Content (%)
100	5-20
100-115	5-15
116-134	5- 7
135	2- 7
136-150	2- 5

Variable	Location	Usage
FLEXPT	/KARD/	Flexible pavement thickness.
I	FP	Tape number for output.
I		T.V.
ICONFIG	/KARD/	Single digit numerical code (1-8) to describe the Design Load Configuration. Codes are: 1=Single Wheel--100 sq in. (645 cm^2) contact area. 2=Twin Assembly Tricycle Gear, 20-in. (508 mm) spacing, 100 sq in. (645 cm^2) contact area for each wheel. 3=Twin Assembly Tricycle Gear, 37-in. (940-mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 4=Single Tandem Assembly Tricycle Gear, 60-in. (1529-mm) spacing, 400 sq in. (2580 cm^2) contact area for each wheel. 5=Twin Tandem Assembly Tricycle Gear, Gear, 31 x 63 in. (787 x 1600 mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 6=Twin Assembly Tricycle Gear, 37-in. (940-mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 7=Twin-Twin Assembly Bicycle Gear, 37 x 62 x 37 in. (940 x 1575 x 940 mm) (940 to 1575 mm) spacing, 267 sq in. (1722 cm^2) contact area for each wheel. 8=Road Load.

Variable	Location	Usage
IFGRP	/KARD/	Soil classification code to describe increasing frost susceptibility on a scale of one to four: Code Frost Group 1 = F1 2 = F2 3 = F3 4 = F4.
IPAVT	/KARD/	Indicates pavement type: 1 = Flexible 2 = Rigid 3 = Both.
ISUBCBR	/KARD/	Value of SUBGRADE.CBR
ISUBHOR	/KARD/	Code indicating horizontal variability of subgrade soil: 1=Uniform 3=Variable 2=Slightly Variable 4=Extremely Variable.
ITEST		Numeric value assigned to TRAFF; positive if TRAFF is numeric, negative if TRAFF is alphabetic.
LCIND	/KARD/	NA
OVR	/KARD/	Defaulted to blank to specify use of flexible minimum thickness tables.
RIGDPT	/KARD/	Rigid pavement thickness.
SMOIST	/KARD/	Water content of the subgrade material (in percent).
SUBMOD	/KARD/	Subgrade Modulus of reaction (k).
TDFP	/KARD/	Total Depth of Frost Penetration (in inches).

Variable	Location	Usage
TRAFF	/KARD/	Traffic area code (alpha-numeric). For airfields, the traffic area (A-E) and for roads, the Design Index (1-10).

Common Blocks

The common block used by OUTA is KARD.

Tapes

The tape used by OUTA is:

TAPE(I) -- writes FROST input to user.

Traceback

Subroutine OUTA is called by FROST.

Illustrations

None.

References

None.

OUTB

Purpose

Subroutine OUTB is used to print error messages from PURIFY.

Formal Parameters

The header card for OUTB appears as follows:

SUBROUTINE OUTB (I).

Description

Subroutine OUTB lists all errors found in the output data as defined in PURIFY. These errors are listed on tape (I) by KWITA through KWITT for subsequent printing in the program output.

Variables

Variable	Location	Usage
I		Tape number for WRITE statements.
KWITA	/BLOCKA/	Error message switch for missing design load.
KWITB	/BLOCKA/	Error message switch for invalid configuration code.
KWITC	/BLOCKA/	Error message switch for invalid traffic area code or invalid design index.
KWITCHS	/BLOCKA/	Array containing message switches.
KWITD	/BLOCKA/	No longer used.
KWITE	/BLOCKA/	Error message switch for incompatible frost criteria.
KWITF	/BLOCKA/	Error message switch for invalid pavement type card.
KWITG	/BLOCKA/	Error message switch for missing pavement thickness.
KWITH	/BLOCKA/	Error message switch for invalid minor code.

Variable	Location	Usage
KWITI	/BLOCKA/	Error message switch for invalid frost group.
KWITJ	/BLOCKA/	Error message switch for subgrade moisture missing.
KWITK	/BLOCKA/	Error message switch for subgrade modulus missing.
KWITL	/BLOCKA/	Error message switch for invalid horizontal variability.
KWITM	/BLOCKA/	Error message switch for missing base moisture content.
KWITN	/BLOCKA/	Error message switch for missing base dry unit weight.
KWITO	/BLOCKA/	Error message switch for base moisture/dry weight incompatibility.
KWITP	/BLOCKA/	Error message switch for invalid dry unit weight.
KWITQ	/BLOCKA/	Error message switch for base CBR incompatibility.
KWITR	/BLOCKA/	Error message switch for invalid CBR.
KWITS	/BLOCKA/	Error message switch for incompatible configuration code/traffic area.
KWITT	/BLOCKA/	Error message switch for invalid flexible override.

Common Blocks

Common block used in OUTB is BLOCKA.

Tapes

The tape used in OUTB is:

TAPE(I) -- writes error messages for user.

Traceback

Subroutine OUTB is called by FROST.

Illustrations

None.

References

None.

AD-A067 691 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAI--ETC F/G 13/2
SYSTEMS APPROACH TO LIFE-CYCLE DESIGN OF PAVEMENTS. VOLUME II. --ETC(U)
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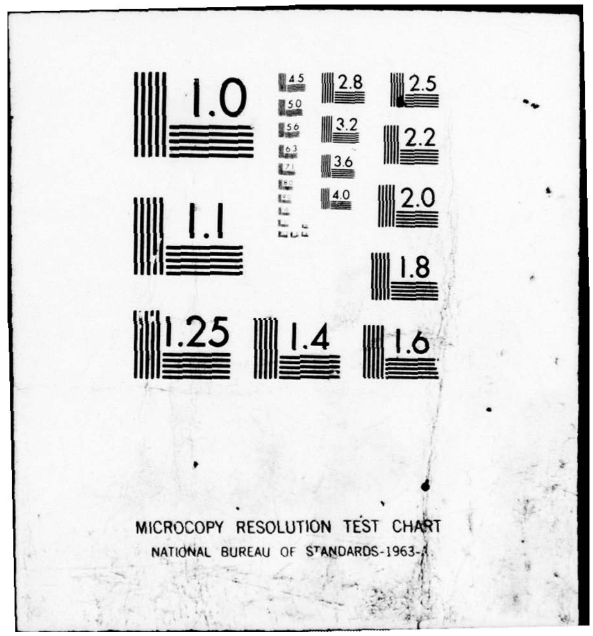
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4.5
5.0
5.6
6.3
7.1
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

OUTC

Purpose

OUTC produces the printed results calculated in FREEZE.

Formal Parameters

The header card for OUTC appears as follows:

SUBROUTINE OUTC (I).

Description

OUTC lists all of the calculated results from FREEZE. These results are placed on Tape I for subsequent printing in the program output.

Variables

Variable	Location	Usage
A		T.V. for flexible thickness.
AKEFT(10)	/ABLK3/	NA
AMINOR	/KARD/	NA
B		T.V. for rigid thickness.
BMOIST	/KARD/	NA
CBR10	/KARD/	NA
CBR8	/KARD/	NA
COMPF	/BLOCKB/	Flexible complete penetration method result.
COMPR	/BLOCKB/	Rigid complete penetration method result.
COMS(4)	/KARD/	NA
DESIGN	/KARD/	NA
DFI	/KARD/	NA
DRYWT	/KARD/	NA

Variable	Location	Usage
FCOMPF	/BLOCKB/	Flexible complete penetration method filter result.
FCOMPR	/BLOCKB/	Rigid complete penetration method filter result.
FDE	/BSBLK/	Estimate of required depth of frost protection (inches) from FROST.DESIGN input.
FDEF	/BSBLK2/	Calculated depth of frost penetration.
FLEXPT	/KARD/	Flexible pavement thickness.
FLSF	/BLOCKB/	Flexible limited subgrade penetration method filter result.
FLSR	/BLOCKB/	Rigid limited subgrade penetration method filter result.
FRSUBF	/BLOCKB/	Flexible reduced strength method filter result.
FRSUBR	/BLOCKB/	Rigid reduced strength method filter result.
I		Tape number variable.
IA		Percent of combined thickness represented by preferred design (40 percent) from TM 5-818-2, para. 13.
IB		Percent of combined thickness represented by preferred design (60 percent) from TM 5-818-2, para. 13.
IBTE	/BSBLK/	NA
IC		Percent of combined thickness represented by preferred design.
ICONFIG	/KARD/	NA
IFGRP	/KARD/	NA

Variable	Location	Usage
IPLEXNA	/BLOCKD/	Flag to print not applicable indication for flexible methods.
IFSWIT(10)	/ABLK3/	NA
IIPAVT	/BLOCKC/	Indicates pavement type: 1=Flexible 2=Rigid 3=Both
IPAVT	/KARD/	Indicates pavement type: 1=Flexible 2=Rigid 3=Both
IRIGDNA	/BLOCKD/	Flag to print not applicable indicator for rigid methods.
ISUBCBR	/KARD/	NA
ISUBHOR	/KARD/	NA
ISWITF	/BLOCKC/	Flexible preferred choice switch.
ISWITR	/BLOCKC/	Rigid preferred choice switch.
ISWITX	/BLOCKE/	Switch for suppression of reduction messages.
MESS(11)	/BLOCKC/	Array equivalenced to the values of MSG1-MSG11.
MSGSW1	/BLOCKC/	Switch to print "APPROVAL" message for Method 1 - complete penetration.
MSGSW2	/BLOCKC/	Switch to print "APPROVAL" message for Method 2 - limited subgrade frost penetration.
MSGSW3	/BLOCKC/	Switch to print "APPROVAL" message for Method 3 - reduced subgrade strength.
MSG01		Temporary switch.

Variable	Location	Usage
MSG02		Temporary switch.
MSG1	/BLOCKC/	Switch used for printing messages.
MSG10	/BLOCKC/	Switch used for printing messages.
MSG11	/BLOCKC/	Switch used for printing messages.
MSG2	/BLOCKC/	Switch used for printing messages.
MSG3	/BLOCKC/	Switch used for printing messages.
MSG4	/BLOCKC/	Switch used for printing messages.
MSG5	/BLOCKC/	Switch used for printing messages.
MSG6	/BLOCKC/	Switch used for printing messages.
MSG7	/BLOCKC/	Switch used for printing messages.
MSG8	/BLOCKC/	Switch used for printing messages.
MSG9	/BLOCKC/	Switch used for printing messages.
OVR	/KARD/	NA
PRDBTF	/BLOCKB/	NA
PRDBTR	/BLOCKB/	NA
PRFLTF	/BLOCKB/	NA
PRFLTR	/BLOCKB/	NA
PVTFLX	/BLOCKD/	Flexible pavement thickness.
PVTRGD	/BLOCKD/	Rigid pavement thickness.

Variable	Location	Usage
RIGDPT	/KARD/	NA
RSUBF	/BLOCKB/	Flexible reduced strength method result.
RSUBR	/BLOCKB/	Rigid reduced strength method result.
SLSDBTF	/BLOCKB/	Flexible limited subgrade penetration method result.
SLSDBTR	/BLOCKB/	Rigid limited subgrade penetration method result.
SLSPENF	/BLOCKB/	Flexible limited subgrade penetration method penetration result.
SLSPENR	/BLOCKB/	Rigid limited subgrade penetration method penetration result.
SMOIST	/KARD/	NA
SUBMOD	/KARD/	NA
TDFP	/KARD/	NA
TRAFF	/KARD/	Traffic area code (alpha-numeric). For airfields, the traffic area (A-E) and for roads, the Design Index (1-10).
XTRA	/BLOCKB/	Message switch for comparing flexible input to flexible table.

Common Blocks

The common blocks used in OUTC are: ABLK3, BLOCKB, BLOCKC, BLOCKD, BLOCKE, BSBLK, BSBLK2, KARD.

Tapes

The tape used in OUTC is:

TAPE (I) -- writes FROST output to user.

Traceback

Subroutine OUTC is called by FROST.

Illustrations

None.

References

None.

APPENDIX G:

OVERLAY (6,0)

OVERLAY (6,0) prints the results of the LIFE2 analysis. The design schemes and overlay strategies, determined in OVERLAY (3,0), are read from TAPE7, costs are calculated, and the results are printed. Earthwork and drainage analyses are included if necessary. The schemes are summarized and ranked according to cost.

RL

Purpose

RL is used to print the results of the LIFE2 analysis.

Formal Parameters

The header card for RL appears as follows:

PROGRAM RL.

Description

As the driver for OVERLAY (6,0), program RL coordinates cost calculations for design schemes and overlay strategies. These costs are ranked and the output for LIFE2 is printed in RL. Figure G1 illustrates the flow of RL.

Variables

Variable	Location	Usage
A		Parameters returning the date of the program run.
AESWL(10)	/WES/	Area (sq in.) used to compute equivalent single-wheel load.
AHH(10)	/HBLK/	NA
ALLCNST		Summary cost of a construction scheme.
AREA	/ARBK/	Area (sq yd) of the pavement section.
AXK	/LCY/	NA

Variable	Location	Usage
BSOVER		Cost of overlay.
CBR(10)	/WES/	Array containing all CBR values.
CCCST(50,10,2)	/CSTBK/	Array for cost curve data where: CCST(I,1,1) is the number of curve segments for variable I; CCCST(I,J,1) is the value on the abscissa for the (J-1) cost data repair; CCCST(IJ2) is the value on the ordinate for the (J-1) cost data pair (i.e., the cost).
CDF		NA
CHAR(7,50)	/RL2/	Contains the segment number for printing the cost parameters.
COVGQ(10,20)	/MIXBLK/	NA
CSTRT(10,6)	/RDSTR/	Array containing TIMES.OF.OVERLAYS: CSTRT(IJ), where I is the strategy number, and J is the index for the year of overlay placement.
CUTPRCE	/TSV/	NA
DLC		Delay cost due to an overlay placement.
DLCF	/CUSR/	Delay cost due to a flexible overlay placement.
DLCR	/CUSR/	Delay cost due to a rigid overlay placement.
DRAIN	/DRNBLK/	Drainage code: 1 = NO 2 = YES 3 = FIXED.DEPTH.
DRNCST	/DRNBLK/	Cost for drainage.
DSCOUNT		Discounted maintenance cost.

Variable	Location	Usage
DSCRPT(3,50)	/RL2/	Array containing cost curve labels used in program output.
DSMAINT(30)		Adjusted strategy cost for the ranked results.
DT	/DOBK/	DTHICKNESS.
DTOTAL		Total discounted maintenance from PREVEN2.
DT2Q	/DOBK/	NA
EARTHWK	/RL1/	Earthwork code: 0 = NO 1 = PAVEMENT 2 = PAVEMENT.PLUS.APPROACH other = fixed cost.
EEP		T.V.
ERCOST	/TSV/	Earthwork cost.
ESWL(10,20)	/WES/	NA
FAC	/LCY/	NA
FACTOR	/RL1/	Geographic cost factor.
FILPRCE	/TSV/	NA
FSTRT(10)		Same as CSTRT (for overlayment of an original flexible pavement).
FTMO(10,4)		Array containing information relative to overlays over an original flexible pavement: FTMO(I,1): 1 = Ith overlay is rigid 2 = Ith overlay is flexible. FTMO(I,2): overlay thickness in inches. FTMO(I,3): 2 = partially bonded rigid overlay 3 = unbonded rigid overlay. FTMO(I,4): XK, the subgrade modulus, on AXK, effective modulus for rigid overlays over asphalt.
HH(10)	/HBLK/	NA
HOLDALL		T.V.

Variable	Location	Usage
HOLDCST		T.V.
HOLDMNT		T.V.
HOLDSCM		T.V.
HOLDSTR		T.V.
I		T.V.
IAREA		Area (sq yd) of the pavement section.
IARF(3)		Array containing the printed symbol for the type of overlay.
IBASE		NA
IBOND		Variable containing the printed symbol for the type of bonding.
IBSTHK		Base course thickness (inches) for a flexible pavement placed as an overlay.
ICBR	/MXBLK/	Number of CBR values in array CBR.
ICK		Indicates whether consecutive strategies use the same original design scheme due to equal original pavement service lives: ICK = 1, new design ICK = 2, same design.
ICMP		Cost index for compacted subgrades.
ID	/DOBK/	Calculation type: 1 = MAINTENANCE 2 = LIFE.CYCLE 3 = DESIGN.
IDENT(3)	/RL1/	IDENTIFICATION.NUMBER.
IDF	/RODLOD/	NA
IDR	/RODLOD/	NA
IDSCRPT(30,10)	/RL2/	Array containing GENERAL.DESCRIPTION.

Variable	Location	Usage
IFAR		Index to print the bonding type.
IFIRST		Equal to 1.
IGINT	/MXBLK/	NA
II		T.V.
III		Cost index for maintenance.
IIL		T.V.
IL		T.V.
ILINE(10)		Indicates which cost curve segment includes the overlay thickness.
IMANQ	/RDSTR/	NA
IMIX	/MIXBLK/	Number of vehicles.
INCHES(10)		Overlay thickness times 100.
IND	/TMPL/	NA
INTHICK		Overlay thickness (inches). (May be the flexible pavement plus base thickness if a flexible pavement and base are placed instead of an overlay.)
INTHK		Overlay thickness (inches). (May be the flexible pavement thickness if a flexible pavement and base are placed instead of an overlay.)
IOVBSE		T.V.
IREST	/RESTR/	Index for DESIGN.RESTRICTION: 1 = NONE 2 = RIGID 3 = FLEXIBLE.
ISCHEME(30)		Array containing the construction scheme numbers to be printed.
ISKIP	/PRVNT1/	NA

Variable	Location	Usage
ISTRAGY(30)		Array containing the strategy numbers to be printed.
ITHICK(10)		Integer value of a design scheme material thickness.
ITY	/DOBK/	Index for DTYPE: 1 = RIGID 2 = FLEXIBLE.
ITYPE(10)		For each material in a design scheme, this array indicates which cost curve segment includes the desired thickness.
IVM	/PRVNT1/	Equals 1 when vehicle maintenance is to be considered.
IX(20)		Contains the flexible material numbers for a design scheme.
IXY		Indicates maintenance type read: 0 = routine maintenance 1 = vehicle maintenance.
IY		T.V.
IYEAR(10)		Array containing the interval between the years of overlays for a strategy.
IYP		Indicates type of overlay: 1 = rigid 2 = flexible.
IZ		T.V.
IZ1		T.V.
IZ2		T.V.
IZ3		Index of the construction cost for a design scheme which is being used for several overlay strategies.
J		T.V.
JA		T.V. (used for cost ranking).
JACK	/TMPL/	Design scheme number.

Variable	Location	Usage
JB		T.V. (used for cost ranking).
JBOND(10)		Array containing the printed symbol for the type of bonding.
JC		Total number of schemes considered.
JCOMB(30)		Array containing the indices of the ranked results for flexible construction schemes.
JCOND	/FLAG/	When equal to 2, causes message to be printed, excluding flexible overlays over completely failed pavements.
JD		Number of ranked results.
JDL	/SCAN3/	Design life in years.
JF		T.V.
JISKIP	/PRVNT1/	Flags existence of routine maintenance data.
JJ		T.V.
JJJ		T.V.
JK		T.V.
JL		T.V.
JLYR		Counter used for flexible materials.
JMANQ	/MANLK/	NA
JOVBSE		T.V.
JREST	/RESTR/	Index for OVERLAY.RESTRICTION: 1 = NONE 2 = RIGID 3 = FLEXIBLE.
JT		T.V.
JTHICK		Cumulative overlay thickness (inches).
JTYPE(3,10)	/RLMN/	Array containing the vehicle names.

Variable	Location	Usage
J1		T.V.
J2		T.V.
J3		T.V.
J4		T.V.
J5		T.V.
J6		T.V.
J7		T.V.
J8		T.V.
K		T.V.
KA		T.V.
KAB		T.V.
KB		T.V.
KC		T.V.
KK		Cost index for flexible pavement materials.
KKK		T.V.
KKNT		T.V.
KLA		Number of vehicles.
KSTH		Integer value of a design scheme total thickness.
K1		Same as IMIX.
K2		Number of parameters for calculating construction costs.
K3		Number of parameters for calculating maintenance costs.
K4	/RL1/	Total number of all construction schemes.

Variable	Location	Usage
K5		Number of overlay strategies.
K7	/RL1/	Number of lines in the general description.
K8		Number of materials in a design scheme.
L		T.V.
LAP		Switch.
LAST		Number of curve segments for a cost parameter.
LIMITL(50)		Lower value of a cost curve segment.
LIMITU(50)		Upper value of a cost curve segment.
LIMU		Number of possible types of strategies: 1 = rigid or flexible 2 = rigid and flexible.
LINE(50)		Array for cost parameters.
LLL		T.V.
LLLAP		Number of ranked flexible results.
LLLAREA		Same as IAREA.
LLP		LLQ + 10.
LLQ		T.V.
LLR		Number of cost curve segments.
LLYR		Total number of materials in a design scheme (from compacted subgrade to surface layer).
LOCATE(8)	/RL2/	Array containing LOCATION.
LPCT		Same as K4.
LPDG		T.V.
LPHS		Message switch.

Variable	Location	Usage
LPP		Total number of rigid and flexible design schemes within a strategy.
LS	/LCY/	Total number of years specified in the TM array.
LZ	/RODLOD/	Indicates road design when equal to 3.
L1		K2 + 1.
L10(50)		Array containing the indices of the possible cost data items.
L11		T.V.
L12		T.V.
L13		NA
L15		Indicates start of vehicle maintenance.
L16		T.V.
L17		Number of vehicle maintenance items.
L18		Number of array DSCRPT members for vehicle maintenance.
L2		K2 + K3.
L3		Index of last data point for a cost item.
L4		T.V.
L5		Total number of cost items possible.
L6		Equal to 1.
L8		Number of cost items that have data.
L9		Number of curve segments for a cost parameter.
M		Cost item index.
MA		T.V.
MB		T.V.

Variable	Location	Usage
MF		T.V.
MG		Single member of array IYEAR.
MH		T.V.
MI		T.V.
MJ		T.V.
MK		T.V.
MLYR		Material number within a layer.
MLYST	/MANLK/	Number of subbase schemes.
MM		Scheme number.
MMM		Index of last cost data point.
MMMM		Strategy number.
MO		T.V.
MW		T.V.
MX		T.V.
MXB		Ranked strategy number.
MXC		Ranked scheme number.
MXX		Strategy number.
MY		T.V.
M3		T.V.
N		T.V.
NA		Counter for year of strategy.
NAME(5)	/RL2/	Array for NAME.OF.BASE.
NB	/LYTD/	Number of base courses.

Variable	Location	Usage
NCOM	/LYTD/	Total number of input compacted subgrades.
NFSTRT		Number of overlays in a strategy over an original flexible pavement.
NKOM		Number of compacted subgrades in a flexible design scheme.
NL		T.V.
NLYR		Number of subbase and compacted subgrades in a flexible design scheme minus 1 (if there are no compacted subgrades, NLYR equals the number of subbases).
NLYST	/NANLK/	Number of compacted subgrade combinations.
NN		T.V.
NNAT	/LTYD/	NA
NNN		Cost index.
NNNN		Number of overlays in a strategy.
NOACFT(50,10)	/RLMN/	Passes/year for each aircraft.
NOD	/NBLK/	NA
NOG	/NBLK/	NA
NOH	/NBLK/	NA
NOO(10)	/RDSTR/	Number of overlays in each strategy.
NOSG	/NBLK/	NA
NPT	/NBLK/	NA
NQLYR		Number of subbases in a flexible design scheme.
NRSTRT		Number of overlays in a strategy over an original rigid pavement.
NSBB	/LYTD/	Total number of input subbase materials.

Variable	Location	Usage
NTH		Switch for thickness accumulation in drainage analysis.
NUMS	/RDSTR/	Number of overlay strategies.
NX	/NBLK/	NA
NY	/NBLK/	NA
OVERLAY		Cost of an overlay.
PRCNT	/MXBLK/	NA
PSTEP	/TSV/	NA
RSTRT(10)		Same as FSTRT, but over rigid pavement.
RTMO(10,4)		Same as FTMO, but over rigid pavement.
SLOPE(50)		Slope of a cost curve segment.
STOREE(10,10)	/MIXBLK/	NA
STORO(10,10)	/MIXBLK/	NA
STRT(10)		Array containing the intervals between overlays in a strategy.
SUM		Thickness (inches) of a design scheme.
SUMAINT(30)		Ranked adjusted strategy cost.
SUMALL(30)		Ranked total adjusted cost.
SUMCNST(30)		Ranked construction cost.
SUMCOST		Sum of total material costs for a design scheme.
SUMSECT		Same as SUMCOST.
SUMUNIT		Sum of the unit costs for a design scheme.
SUMUSE		Sum of the user costs for an overlay strategy.
SVCOST		NA

Variable	Location	Usage
SWID	/TMPL/	NA
TATAL(35)	/TTL/	Itemized maintenance costs for each year in an overlay strategy.
THCK	/TSV/	T.V. (for thickness).
THFF(20)	/THKBK/	Required flexible pavement thickness required above the subgrade CBR at the times specified in the TM array.
TICK		Thickness of the pavement above the compacted subgrades for drainage analysis.
TM(20)	/HBLK/	Array containing the specific years at which pavement thickness calculations are to be made.
TMO(10,4)		Same as FTMO (for any pavement type).
TMT(20)		Material thicknesses for a design scheme.
TOTAL		Total adjusted cost for a design scheme and an overlay strategy.
TOTCOST		Total cost for a material in a design scheme.
TRKK(20)	/THKBK/	NA
TRPQZ(20)	/PQZ/	Required rigid pavement thickness at the times specified in the TM array.
TRST	/DMBLK/	Present worth factor including DISCOUNT and ESCALATION.RATE.
TRY(20)	/LCY/	NA
TT		Slab thickness for a rigid design scheme.
TWOCL	/TMPL/	NA
T1		Base thickness for a rigid design scheme.
UNITCST		User cost for a year in an overlay strategy.
USECOST		User cost for a year in an overlay strategy.

Variable	Location	Usage
W		Tape number for debug file.
WHEELS(10)	/WES/	NA
WMAINT		Total of all maintenance costs for an overlay strategy.
WOVERLY		Total overlay cost for a strategy.
WTOTAL		Total cost for a strategy.
XA		T.V.
XCBR	/LCY/	Subgrade CBR.
XD		T.V.
XE		T.V.
XF		T.V.
XFP(20,10)	/SG5WP2/	Array containing the required thicknesses of pavement for different CBRs at different times; XFP(I,J) is THFF(I) for CBR(J).
XINTRS		Same as TRST.
XK	/NBLK/	Subgrade modulus, pci.
XMAINT		Total of all maintenance costs for 1 year in an overlay strategy.
XMT(10,6)	/LYTD/	NA
XSTR	/LCY/	Concrete flexural strength (psi).
XTHICK(10)		Material thicknesses for a design scheme.
XTOTAL		Adjusted strategy cost.
YCBR(10,4)	/LYTD/	NA
YEARCST		Total cost for one year for an overlay strategy.
YINTER(50)		Ordinate intercept for a cost curve segment.

Variable	Location	Usage
YK	/LCY/	NA
YTOTAL		Total adjusted cost for a strategy and scheme.
Z		Tape number for the LIFE2 output.
ZCBR(10,6)	/LYTD/	NA
ZMT(3,4)	/LYTD/	Array containing the CBR values for up to three base materials where ZMT(I,1) is the CBR of layer I.

Common Blocks

The common blocks in RL are as follows:

ARBK, CSTBK, CUSR, DMBLK, DOBK, DRNBLK, FLAG, HBLK, LCY, LYTD, MANLK, MIXBLK, MXBLK, NANLK, NBLK, PQZ, PRVNT1, RDSTR, RESTR, RLMN, RL1, RL2, RODLOD, SCAN3, SG5WP2, THKBK, TMPL, TSV, TTL, WES.

Tapes

The following tapes are used in RL:

TAPE7--contains overlay strategy information, and rigid and flexible design schemes
TAPE(W)--writes to the debug file
TAPE(Z)--is the LIFE2 output file.

Traceback

Program RL is called by MAIN as the driver of OVERLAY (6,0) and calls DATE, DRNAGE6, EXCOST6, PREVEN2, and the inline functions FLOAT and INT.

Illustrations

Figure G1 is a descriptive flowchart of RL.

References

None.

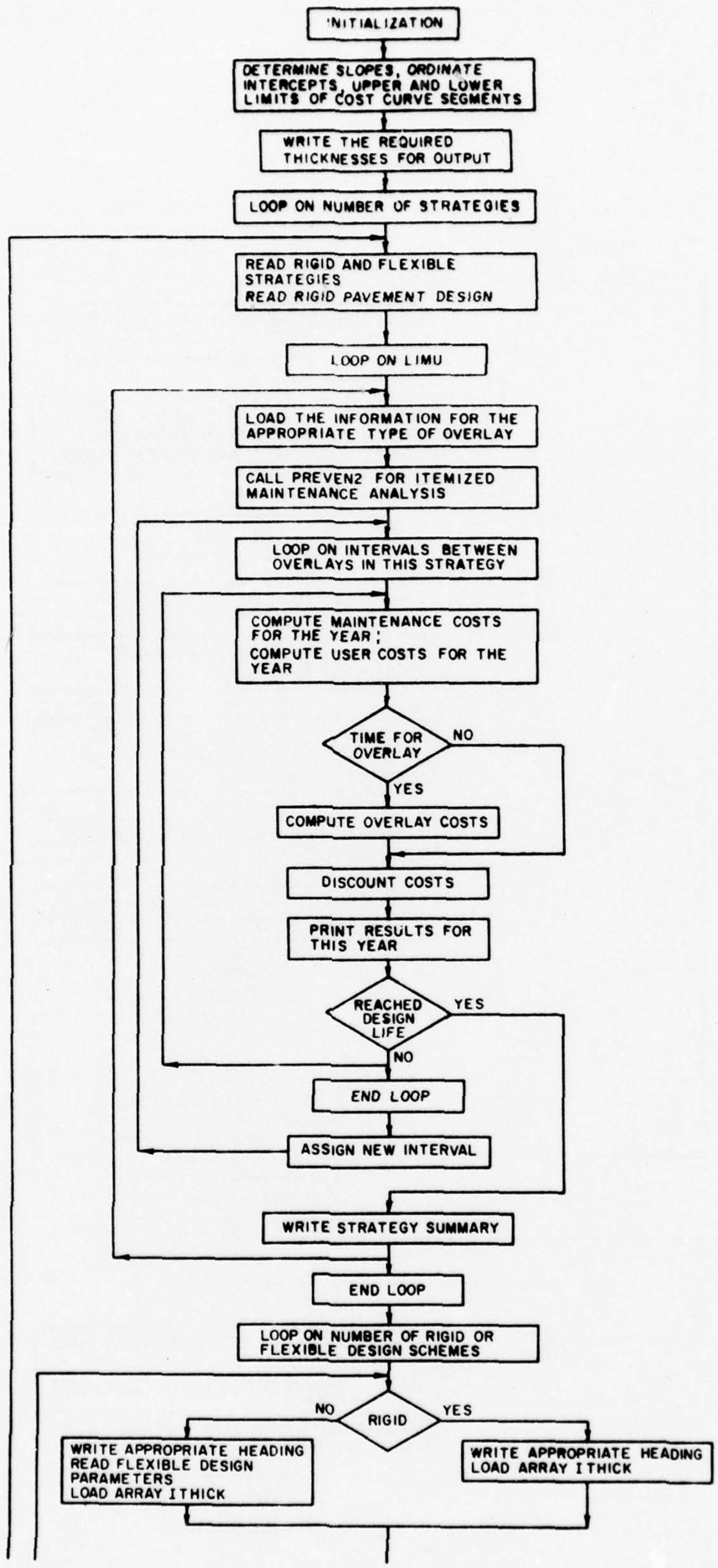


Figure G1. Flowchart for RL.

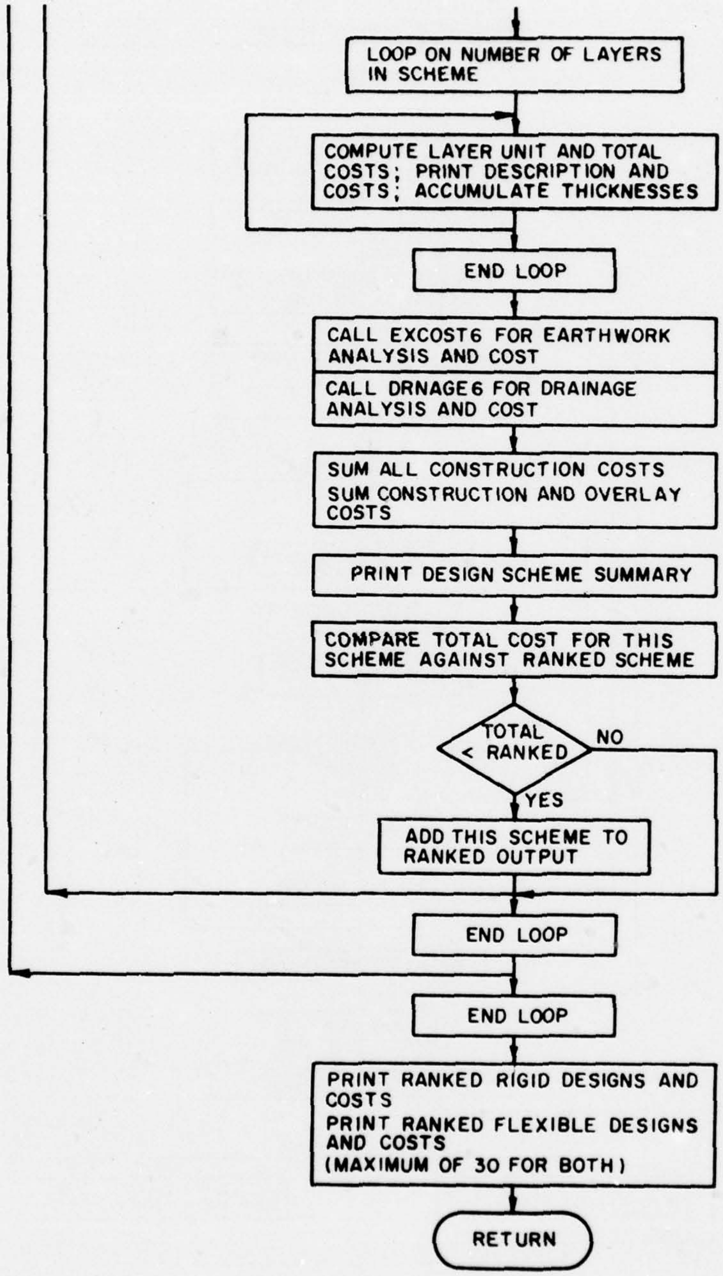


Figure G1. (con't)

EXCOST6

Purpose

EXCOST6 is used to calculate earthwork costs and write cost and volume information.

Formal Parameters

The header card for EXCOST6 appears as follows:

SUBROUTINE EXCOST6.

Description

Subroutine EXCOST6 calculates the total cost of earthwork based on the volume of earth to be moved and the unit cost $/cu yd. It uses the average end areas from OVERLAY (4,0) to calculate earthwork volume. The cost and volume information for cut, fill, and total excavation are derived in EXCOST6. (This subroutine is similar to EXCOST3 in OVERLAY (3,0).)

Variables

Variable	Location	Usage
A		End area (sq yd).
APREND(9,3)	/ZONES/	NA
APRSTR(9,3)	/ZONES/	NA
APTOT	/ZONES/	Total cost of approach-zone earthwork.
APWID(9)	/ZONES/	NA
B		End area (sq yd).
BSTK	FP	Base thickness.
CUT		Volume of cut (cu yd).
CUTCST	/TSV/	Total cost of cut ($).
CUTPRCE	/TSV/	Unit cost of cut ($/cu yd).
ERCOST	/TSV/	Total cost of earthwork ($).

Variable	Location	Usage
FILCST		Total cost of fill.
FILL		Volume of fill (cu yd).
FILPRCE	/TSV/	Unit cost of fill ($/cu yd).
I		T.V.
IFL		Index for end-of-file: Zero - no end-of-file encountered; Non-Zero - end-of-file encountered.
IK		T.V.
IND	/TMPL/	NA
JACK	/TMPL/	NA
NAPR	/ZONES/	NA
NERTH	/TSV/	Number of unique thicknesses.
PSTEP	/TSV/	Length of prism used in average end area volume calculations (feet).
SAVER(50,2)		Array containing costs and thicknesses: SAVER(I,1) = thickness. SAVER(I,2) = cost.
SWID	/SMPL/	Width of pavement (feet).
THCK	/TSV/	Base thickness plus pavement thickness (inches).
TPAV	FP	Required thickness of rigid pavement.
TWOCL	/TMPL/	NA
VOL		Volume of earthwork (cu yd).
ZONSTEP(9)	/ZONES/	NA

Common Blocks

Common blocks in EXCOST6 are:

TMPL, TSV, ZONES.

Tapes

Tapes used by EXCOST6 are:

TAPE2 = reads the end areas.
TAPE4 = writes the results for the LIFE2 output.

Traceback

Subroutine EXCOST6 is called by BTOT and calls EOF.

Illustrations

None.

References

None.

DRNAGE6

Purpose

DRNAGE6 performs the subsurface drainage analysis and writes the total subsurface drainage cost and drainage design information.

Formal Parameters

The header card for DRNAGE6 is:

SUBROUTINE DRNAGE6(TTHICK).

Description

This analysis first determines whether frost penetration or ground water depth will necessitate underdrains. In addition, it checks if the user has specified that underdrains are required for surface flooding, a sag vertical curve, or underground seepage. If underdrains are unnecessary, the analysis is terminated, and this conclusion is printed in the program output.

If underdrains are required, the greatest depth required by frost, ground water, or user criteria is determined. The pipe spacing is then determined with pipes assumed at both edges of the pavement. If the quantity of water exceeds pipe capacity, underdrains are also placed at the pavement section's quarter points. The required pipe diameter, construction quantities and costs, and a cost per lineal foot of pipe are calculated. A cost estimate is then derived for laterals and outlets based on user input and the cost per lineal foot. Finally, the total subsurface drainage cost and pertinent underdrain geometry are printed.

Variables

Variable	Location	Usage
AKEF	/AKBLK/	NA
AKY	/AKBLK/	NA
ALOS	/SA/	Length of section (feet).
BSTK	FP	Base thickness.
BIG	/AKBLK/	NA
BTE	/BSBLK/	NA

Variable	Location	Usage
CAVCST		Unit excavation cost ($/cu yd).
CAVCSTO	/DRNBLK2/	Unit excavation cost ($/cu yd).
CSTLF		Total cost per lineal foot of excavation, filter material, and pipe.
CUTPRCE	/TSV/	NA
DGWT		Depth to ground water (inches).
DIP		Real value of IDIPO.
DL		Drainage length--transverse direction (feet).
DLO	/DRNBLK2/	Drainage length--transverse direction (feet).
DRAIN	/DRNBLK/	Index for DRAINAGE: 0 = no 1 = yes 2 = fixed depth.
DRNCST	/DRNBLK/	Total drainage cost.
DTP		Depth to pipe (inches).
DTPT		Pavement thickness plus base thickness and distance to water table (or total depth of frost penetration).
EP		Effective porosity of base course (decimal).
EPO	/DRNBLK2/	Effective porosity of base course (decimal).
ERCOST	/TSV/	NA
EXCAV		Volume of excavation (cu yd).
EXCVCST		Total excavation cost ($).
FCTR		Number of drainage lines: 2 when TIME < 10.0 days 4 when TIME > 10.0 days.

Variable	Location	Usage
FDE	/BSBLK/	Required depth of frost protection for FROST.DESIGN (inches).
FDEF	/BSBLK2/	Calculated depth of frost protection (inches).
FILCST		Unit filter material cost ($/cu yd).
FILCSTO	/DRNBLK2/	Unit filter material cost ($/cu yd).
FILPRCE	/BSBLK/	NA
FILTER		Volume of filter material (cu yd).
FMCST		Total filter material cost ($).
GBM	/BSBLK/	NA
H2F		Distance from bottom of base to FDE (inches).
H2WT		Distance from bottom of base to water table (inches).
H3		Base thickness plus height of cross slope (half of cross slope if 50 percent drainage requires more than 10 days).
H3O	/DRNBLK2/	Height of cross slope (feet).
FBTE	/BSBLK/	Index for BASE.TRADEOFF and FROST.DESIGN (see below)

	BASE.TRADEOFF	FROST.DESIGN
1 -	NO	
2 -	Estimate	
3 -	Tradeoff	
4 -	Tradeoff	read FROST
5 -	Tradeoff	calculate FROST
6 -	NO	calculate FROST

Variable	Location	Usage
IDGWTO	/DRNBLK2/	Depth to ground water table (inches).
IDIPO	/DRNBLK2/	User specified depth to pipe (inches).
IND	/TMPL/	NA
JACK	/TMPL/	Design scheme number.

Variable	Location	Usage
KD		Index for drainage information: 1 = Drainage not required 3 = Frost controls 4 = Water table controls.
KDFLAG		Index: when equal to 2, user has specified depth; when not equal to 2, the assigned KD values.
LENGTH		Length (feet).
LENGTHO	/DRNBLK2/	Length (feet).
LOUT		Average length of outlet pipe (feet).
LOUTO	/DRNBLK2/	Average length of outlet pipe (feet).
NOUT		Enters as outlet code (see NOUTO); changes to number of outlets required.
NOUTO	/DRNBLK2/	Outlet code: 0 = all outlets considered 1 = all outlets drain to one side 2 = outlets drain to both sides.
PAVT	/AKBLK/	NA
PERM		Permeability of base course (ft/min).
PERMO	/DRNBLK2/	Permeability of base course (ft/min).
PIPCST		Unit cost of pipe ($/lin ft) (purchase and placement).
PIPCSTO	/DRNBLK2/	Unit cost of pipe ($/lin ft) (purchase and placement).
PIPECST		Unit cost of pipe ($/lin ft)
PSTEP	/TSV/	NA
Q		Flow rate (cfs).
R		Radius of drainge pipe (inches).

Variable	Location	Usage
RN		Manning Roughness Factor (decimal): .013 - smooth pipe .024 - corrugated pipe.
RNO	/DRNBLK2/	Manning Roughness Factor (decimal): .013 - smooth pipe .024 - corrugated pipe.
SL		Longitudinal slope (ft/ft).
SLENGTH		Length of lateral lines (feet).
SLO	/DRNBLK2/	Longitudinal slope (ft/ft).
SWID	/TMPL/	NA
T		Base thickness plus pavement thickness.
TBAS		Base thickness (inches).
TBS	/AKBLK/	NA
THCK	/TSV/	Pavement thickness plus base thickness (inches).
TIME		Time in days for 50 percent drainage.
TOL	/BSBLK/	NA
TTHICK	FP	Pavement thickness (inches).
TWOCL	/TMPL/	NA
WOS	SA	NA

Common Blocks

Common blocks in DRNAGE6 are:

AKBLK, BSBLK, BSBLKL2, DRNBLK, DRNBLK2, SA, TSV, TMPL.

Tapes

Tapes used by DRNAGE6 are:

TAPE12 -- contains the drainage analysis results for the LIFE2 output.

TAPE6 -- contains information for the debug file.

Traceback

Subroutine DRNAGE6 is called by RL and calls the inline functions AINT, FLOAT, and IFIX.

Illustrations

Figure G2 is a descriptive flowchart of DRNAGE6.

References

Drainage and Erosion Control--Subsurface Drainage Facilities for Airfields TM 5-820-2 (Department of the Army, August 1965).

Ernest F. Brater, and Horace Williams King, *Handbook for Hydraulics* (McGraw-Hill, Inc., 1976), Equation 6-26f.

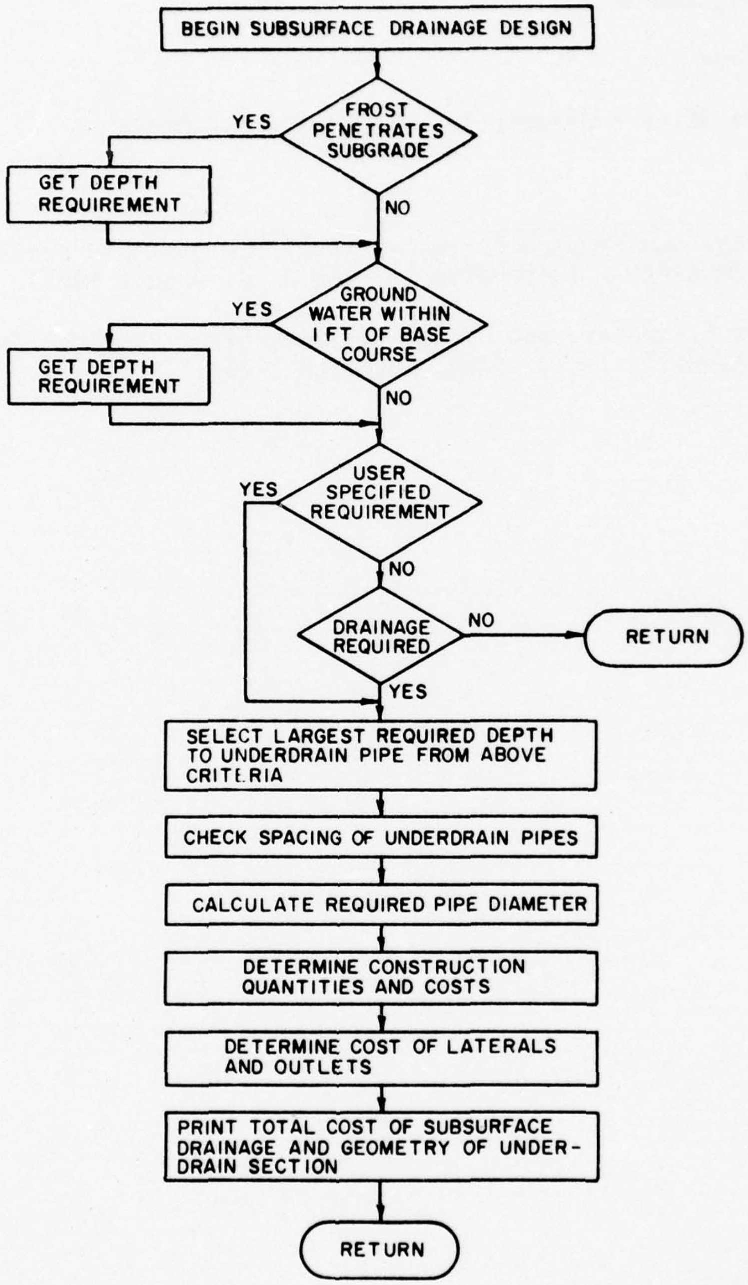


Figure G2. DRNAGE6 flowchart.

PREVEN2

Purpose

PREVEN2 totals the itemized maintenance costs for an overlay strategy.

Formal Parameters

The header card for PREVEN2 appears as follows:

SUBROUTINE PREVEN2(TMO,STRT,NSTRT,DTOTAL,MMMM,TT,ITY).

Description

PREVEN2 controls calls to RIGI2 and FLEXB2 which calculate the itemized maintenance strategy costs. Total costs and total discounted costs are returned. Figure G3 shows the flow of this subroutine.

Variables

Variable	Location	Usage
DTOTAL	FP	Total discounted maintenance cost for this strategy.
I		T.V.
ICHECK		NA
IEND		Counter for last year of overlay.
INDXRF(35)	/NDXRF/	Array containing overlay tape for the years of overlays: 1 = rigid 2 = flexible 3 = no overlay for this year.
ISTART		Counter for first year of overlay.
ITY		Index for DESIGN.TYPE (DTYPE): 1 = rigid 2 = flexible.
J		T.V.
JDL	/SCAN3/	Design life of pavement in years.

Variable	Location	Usage
KK		Counter for overlays.
L		T.V. for previous year. (Also used as tape number index.)
MAXYR		Design life of pavement in years.
MMMM	FP	Variable for trial number.
NSTRT	FP	Number of overlays in a particular strategy.
STRT(10)	FP	Array containing years of overlays.
TCLNDRN		Total cost for MAINTAIN.DRAINS.
TCLNSWP		Total cost for CLEANING.SWEEPING.FLEXIBLE. PAVEMENT.
TDTOT		Total discounted maintenance cost for flexible materials.
TMO(10,4)	FP	Array containing overlay information: TMO(I,1): 1 - rigid overlay 2 - flexible overlay. TMO(I,2): overlay thickness (inches). TMO(I,3): 2 - partial bond 3 - unbonded. TMO(I,4): XK, the subgrade modulus, or AXK, effective subgrade modulus over asphalt.
TOTALS		Total maintenance cost for this strategy.
TRKK		Total thickness of pavement overlay since first rigid overlay on pavement.
TT	FP	Slab thickness.
TTCRPT		Total cost for CRACKSEALING.FLEXIBLE.PAVEMENT.
TTOT		Total maintenance cost for flexible materials.

Variable	Location	Usage
TTSLCT		Total cost for SURFACE.TREATMENT.FLEXIBLE. PAVEMENT.
XCLEAN	FP	Total cost for CLEANING.SWEEPING.RIGIDPAVEMENT.
XDISTOT	FP	Total cost with DISCOUNT and ESCALATION.RATE included.
XREPAIR	FP	Total cost for REPAIR.SCALING.POPOUTS. RIGIDPAVEMENT.
XRESLAB	FP	Total cost for REPLACE.SLABS.RIGIDPAVEMENT.
XSLJNT	FP	Total cost for SEALING.JOINTS.CRACKS.RIGIDPAVEMENT.
XTOTAL	FP	Total cost of repairing scales and popouts, sealing joints and cracks, replacement of slabs, and cleaning and sweeping costs.

Common Blocks

The common blocks in PREVEN2 are: NDXRF, SCAN3.

Tapes

The tape used in PREVEN2 is:

TAPE8 -- contains a summary message for the output.

Traceback

Subroutine PREVEN2 is called by RL and calls RIGI2 and FLEXB2 and the inline function INT.

Illustrations

Figure G3 is a descriptive flowchart of PREVEN2.

References

None.

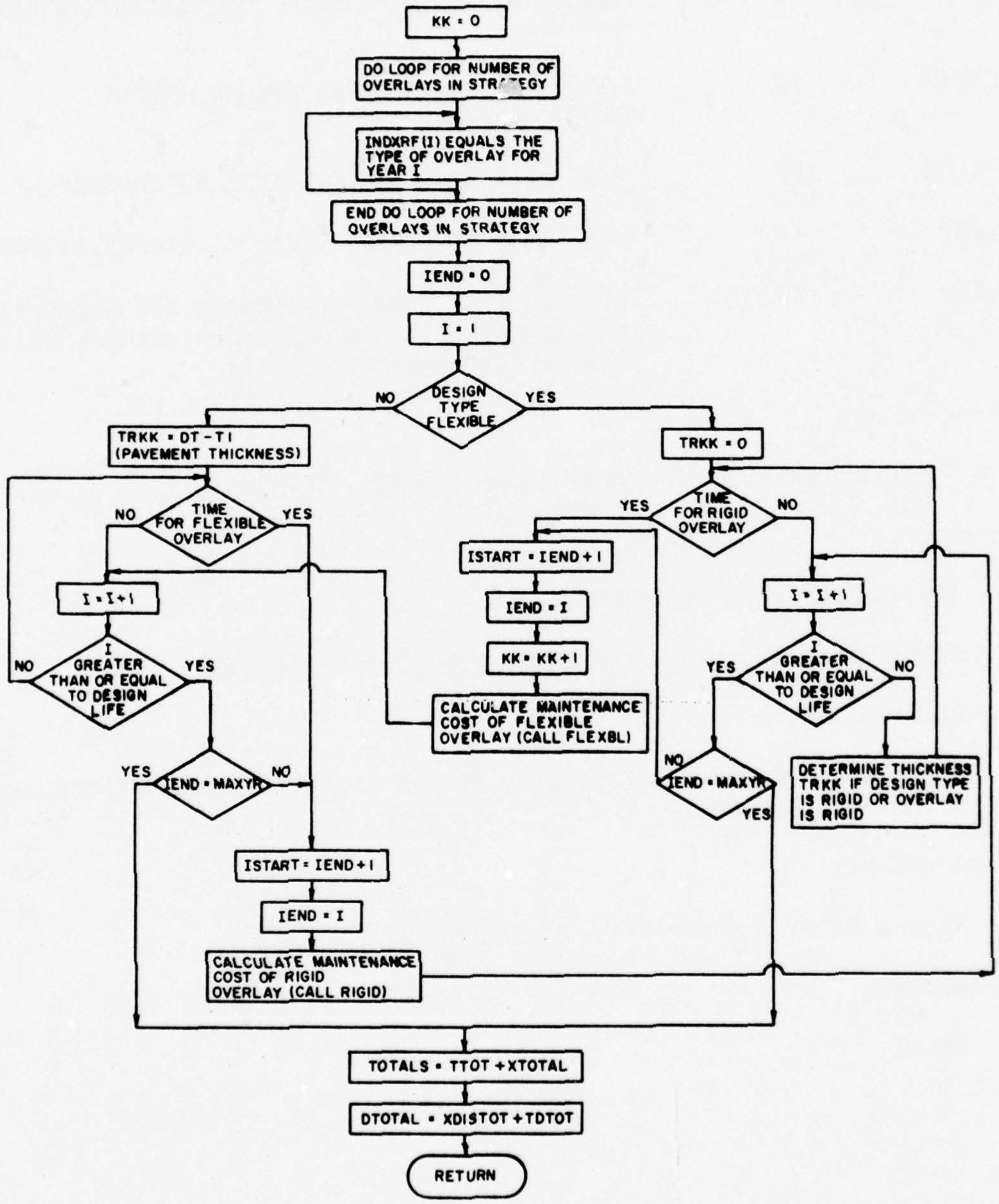


Figure G3. PREVEN2 flowchart.

FLEXB2

Purpose

The itemized maintenance costs for flexible design schemes are calculated in FLEXB2.

Formal Parameters

The header card for FLEXB2 appears as follows:

SUBROUTINE FLEXB2(TTSLCT,TTCRPT,TCLNDRN,TCLNSWP,TTOT,TDTOT,MMMM, ISTART,IEND).

Description

This subroutine computes the costs of maintenance activities at appropriate times for flexible pavements. Figure G4 illustrates the procedure used.

Variables

Variable	Location	Usage
AREA	/ARBK/	Area (sq yd).
CCLNDRN(35)		Array containing cost factors for MAINTAIN.DRAINS.
CCLNSWP(35)		Array containing cost factors for CLEANING. SWEEPING.FLEXIBLE.PAVEMENT.
CLNDRN	/PRVNT/	Cost/sq yd for MAINTAIN.DRAINS.
CLNSWP	/PRVNT/	Cost/sq yd for CLEANING.SWEEPING.FLEXIBLE.PAVEMENT.
COSTF		Cost/sq yd for OTHER.MAINTENANCE.FLEXIBLE.PAVEMENT.
COSTR		NA
CRKPTCH(35)		Array containing cost factors for PATCHING. FLEXIBLE.PAVEMENT and/or CRACKSEALING.FLEXIBLE. PAVEMENT.
CRSL	/PRVNT/	Cost/sq yd for CRACKSEALING.FLEXIBLE.PAVEMENT.
DTOT		Total discounted maintenance cost for 1 year.
FACTR1	/PRVNT/	NA

Variable	Location	Usage
FACTR2	/PRVNT/	NA
FACTR3	/PRVNT/	NA
FLXMAN		Cost for OTHER.MAINTENANCE.FLEXIBLE.PAVEMENT.
FLXPAR		Cost in a specific year for OTHER.REPAIRS. FLEXIBLE.PAVEMENT.
FRSTSL	/PRVNT/	NA
I		T.V.
ICYCLE	/PRVNT/	NA
IDQ	/DOBK/	NA
IEND	FP	Counter for year at end of overlay.
IFL	/PRVNT/	Number of cost pairs for OTHER.REPAIRS. FLEXIBLE.PAVEMENT.
IJ		Counter for number of seal coats required.
INDXRF(35)	/NDXRF/	Array containing overlay type at each year of overlays: 1 = rigid 2 = flexible.
IREST	/RESTR/	Index for DESIGN.RESTRICTION: 1 = none 2 = rigid 3 = flexible.
IRG	/PRVNT/	NA
ISTART	FP	First year of overlay.
ISTRT		First year of overlay.
ITY		Index for DESIGN.TYPE (DTYPE): 1 = rigid 2 = flexible.
IYR		Year for flexible pavement placement.

Variable	Location	Usage
J		Tape number index.
JCYCLE		Time interval between occurrences of MAINTAIN.DRAINS.
JDL	/SCAN3/	Design life of pavement in years.
JREST	/RESTR/	NA
JS		Counter for OTHER.REPAIRS.FLEXIBLE.PAVEMENT.
JYR		Number of years without sealcoating.
L		Number of years since overlay placement.
MMMM	FP	Counter for trial number.
NFL	/PRVNT/	Time interval between occurrences of OTHER. MAINTENANCE.FLEXIBLE.PAVEMENT.
NRG	/PRVNT/	NA
PATCH		Total cost for PATCHING.FLEXIBLE.PAVEMENT.
PTCH	/PRVNT/	Cost/sq yd for PATCHING.FLEXIBLE.PAVEMENT.
REPFL(10,2)	/PRVNT/	Array for OTHER.REPAIRS.FLEXIBLE.PAVEMENT: REPFL(I,1) is the year REPFL(I,2) is the cost for that year.
REPRG(10,2)	/PRVNT/	NA
SCLPOP	/PRVNT/	NA
SEALYR(15)		Array containing years at which sealcoating is required.
SITLE(8)		Character array containing titles of maintenance costs.
SLCOAT(35)		Array containing cost factor for SURFACE. TREATMENT.FLEXIBLE.PAVEMENT.

Variable	Location	Usage
SLCT	/PRVNT/	Cost/sq yd for SURFACE.TREATMENT.FLEXIBLE.PAVEMENT.
TCLNDRN	FP	Total cost for MAINTAIN.DRAINS.
TCLNSWP	FP	Total cost for CLEANING.SWEEPING.FLEXIBLE.PAVEMENT.
TDTOT	FP	Total discounted maintenance cost for flexible layers.
TOT		Total cost for a given year.
TOTAL(35)	/TTL/	Array containing total cost per year.
TRST	/DMBLK/	Economic factor which combines DISCOUNT and ESCALATION.RATE.
TTCRPT	FP	Total cost for CRACKSEALING.FLEXIBLE.PAVEMENT.
TTOT	FP	Total itemized maintenance cost for 1 year.
TTSLCT	FP	Total cost for SURFACE.TREATMENT.FLEXIBLE. PAVEMENT.

Common Blocks

Common blocks in FLEXB2 are:

ARBK, DMBLK, DOBK, NDXRF, PRVNT, RESTR, SCAN3, TTL.

Tapes

TAPE8 -- writes the results for 1 year on the LIFE2 output file.

Traceback

Subroutine FLEXB2 is called by RL and calls the inline function INT.

Illustrations

Figure G4 is a flowchart of FLEXB2.

References

None.

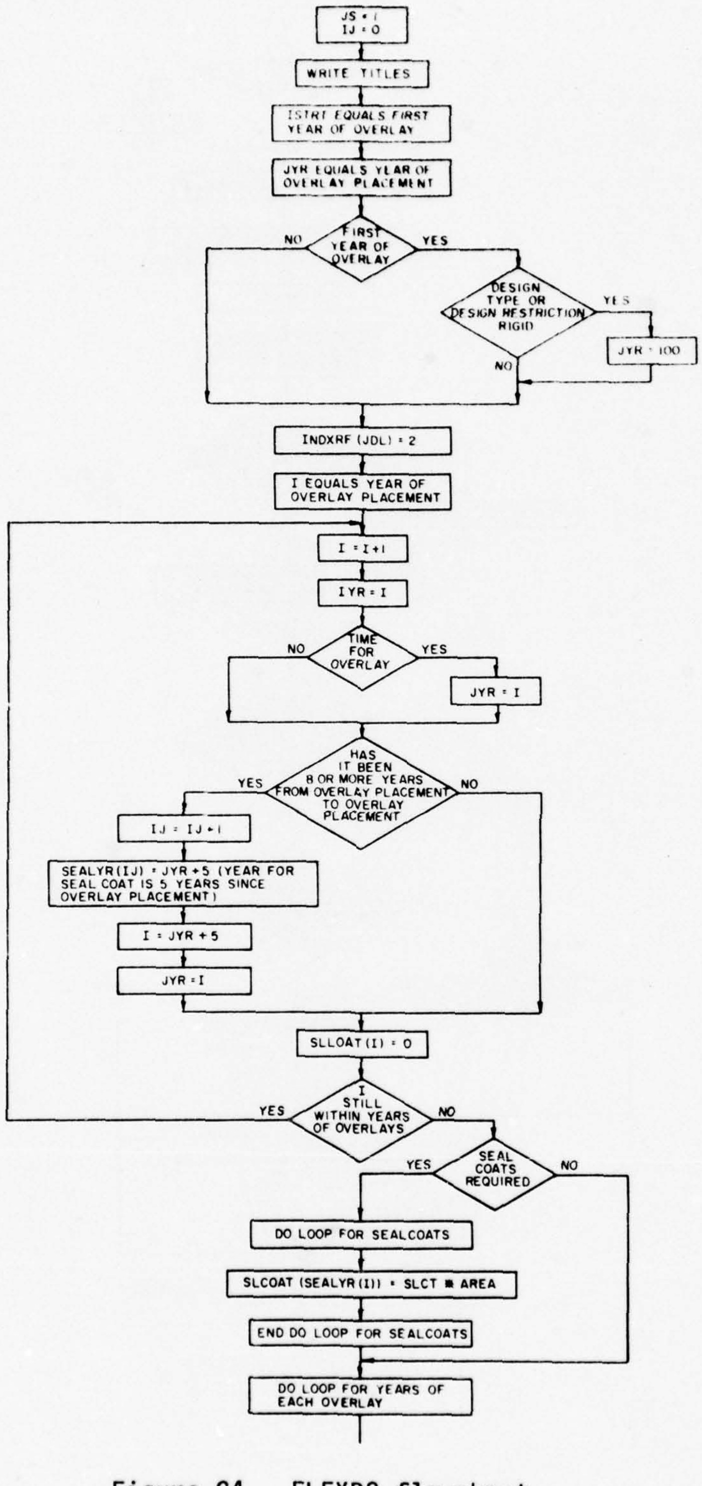


Figure G4. FLEXB2 flowchart.

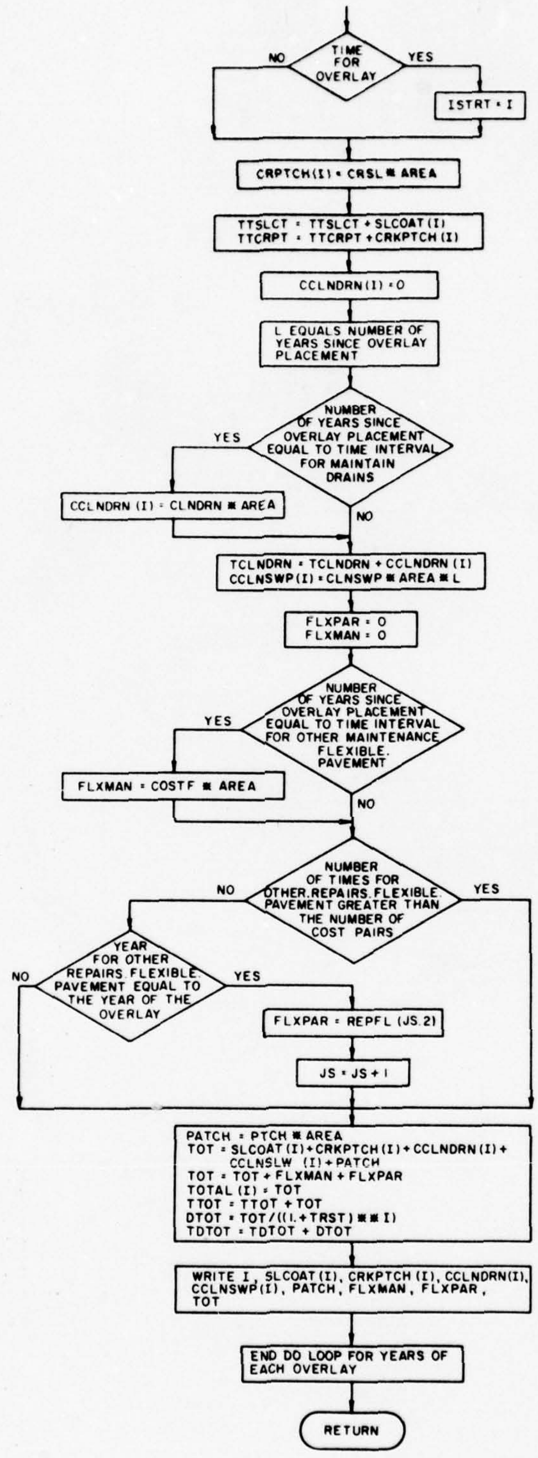


Figure G4. (cont'd)

RIGI2

Purpose

This routine calculates the itemized maintenance costs for rigid layers.

Formal Parameters

The header card for RIGI2 appears as follows:

SUBROUTINE RIGI2(XREPAIR,XSLJNT,XRESLAB,XCLEAN,XDISTOT,XTOTAL,KK.
TRKK,ISTART,IEND,TMO).

Description

This subroutine computes the costs of maintenance activities at appropriate times for M&R of rigid pavements. Figure G5 illustrates the procedures used.

Variables

Variable	Location	Usage
AREA		Maintenance area considered (sq yd).
CLEAN		Cost factor for CLEANING.SWEEPING.RIGIDPAVEMENT.
CLNDRN	/PRVNT/	Cost/sq yd for MAINTAIN.DRAINS.
CLNSWP	/PRVNT/	NA
COSTF	/PRVNT/	NA
COSTR	/PRVNT/	Cost/sq yd for OTHER.MAINTENANCE.RIGIDPAVEMENT.
CRSL	/PRVNT/	NA
DISTOT		Discounted value of TOTAL for 1 year.
DRAINS		Cost factor for MAINTAIN.DRAINS.
FACTR1	/PRVNT/	Cost/sq yd for SEALING.JOINTS.CRACKS.RIGIDPAVEMENT.
FACTR2	/PRVNT/	Cost/sq yd for CLEANING.SWEEPING.RIGIDPAVEMENT.
FACTR3	/PRVNT/	Cost/sq yd for REPLACE.SLABS.RIGIDPAVEMENT.

Variable	Location	Usage
FRSTSL	/PRVNT/	NA
I		T.V.
ICYCLE	/PRVNT/	Cyclic period for sealing joints and cracks.
IEND	FP	Counter for year of end of overlay.
IFL	/PRVNT/	NA
INDXRF	/NDXRF/	Array containing overlay type for the years of overlays: 1 = rigid 2 = flexible 3 = no overlay this year.
IRG	/PRVNT/	Number of cost pairs for OTHER.REPAIRS.RIGIDPAVEMENT.
ISTART	FP	First year of overlay.
ISTRT		First year of overlay.
JCYCLE	/PRVNT/	Time interval between occurrences of MAINTAIN.DRAINS.
JDL	/SCAN3/	Design life of pavement in years.
KK	FP	Number of overlays.
KREP		Year for OTHER.REPAIRS.RIGIDPAVEMENT.
KS		Counter for OTHER.REPAIRS.RIGIDPAVEMENT.
MMMM	FP	Stategy number.
NA		TV (for the number of years since overlay placement).
NB		Difference in years between overlays.
NC		Index indicating number of years since placement of overlay.
NFL	/PRVNT/	NA

Variable	Location	Usage
NRG	/PRVNT/	Interval in years between the activity OTHER.MAINTENANCE.RIGIDPAVEMENT.
PERCENT(25)		Percentage of slab area to be replaced in the Ith year.
PTCH	/PRVNT/	NA
REPAIR		Cost factor for REPAIR.SCALING.POPOUTS.RIGIDPAVEMENT.
REPFL(10,2)	/PRVNT/	Array for OTHER.REPAIRS.FLEXIBLE.PAVEMENT: REPFL(I,1) is the year REPFL(I,2) is the cost for that year.
REPRG(10,2)	/PRVNT/	Array for OTHER.REPAIRS.RIGIDPAVEMENT: REPRG(I,1) is the year REPRG(I,2) is the cost for that year.
RESLAB		Cost factor for REPLACE.SLABS.RIGIDPAVEMENT.
RIGMAN		Cost factor for OTHER.MAINTENANCE.RIGIDPAVEMENT.
RIGPAR		Cost for OTHER.REPAIRS.RIGIDPAVEMENT.
SCLPOP	/PRVNT/	Cost/sq yd for REPAIR.SCALING.POPOUTS.RIGIDPAVEMENT.
SLCT	/PRVNT/	NA
SLJNT		Cost factor for SEALING.JOINTS.CRACKS.RIGIDPAVEMENT.
TITLE(8)		Titles of maintenance items.
TMO(10,4)	FP	Array containing overlay information: TMO(I,1): 1 - rigid overlay 2 - flexible overlay. TMO(I,2): overlay thickness. TMO(I,3): 2 - partial bond 3 - unbonded. TMO(I,4): XK, subgrade modulus or AXK, effective subgrade modulus over asphalt.

Variable	Location	Usage
TOTAL(35)	/TTL/	Sum of repairing scales and popouts, sealing joints and cracks, replacement of slabs, and cleaning and sweeping costs for each year.
TRKK	FP	Total thickness of pavement overlay since first rigid overlay on pavement.
TRST	/DMBLK/	Economic factor which combines DISCOUNT and ESCALATION.RATE.
XCLEAN	FP	Total cost for CLEANING.SWEEPING.RIGIDPAVEMENT.
XDISTOT	FP	Total discounted maintenance cost for rigid layers.
XREPAIR	FP	Total cost for REPAIR.SCALING.POPOUTS.RIGIDPAVEMENT.
XRESLAB	FP	Total cost for REPLACE.SLABS.RIGIDPAVEMENT.
XSLJNT	FP	Total cost for SEALING.JOINTS.CRACKS.RIGIDPAVEMENT.
XTOTAL	FP	Total cost of repairing scales and popouts, sealing joints and cracks, replacement of slabs, and cleaning and sweeping costs.

Common Blocks

Common blocks in RIGI2 are:

ARBK, DMBLK, MDXRF, PRVNT, SCAN3, TTL.

Tapes

The tape used by RIGI2 is:

TAPE8 -- writes the yearly results to the LIFE2 output.

Traceback

Subroutine RIGI2 is called by PREVENT and calls the inline function INT.

Illustrations

Figure G5 is a descriptive flowchart of RIGI2.

References

None.

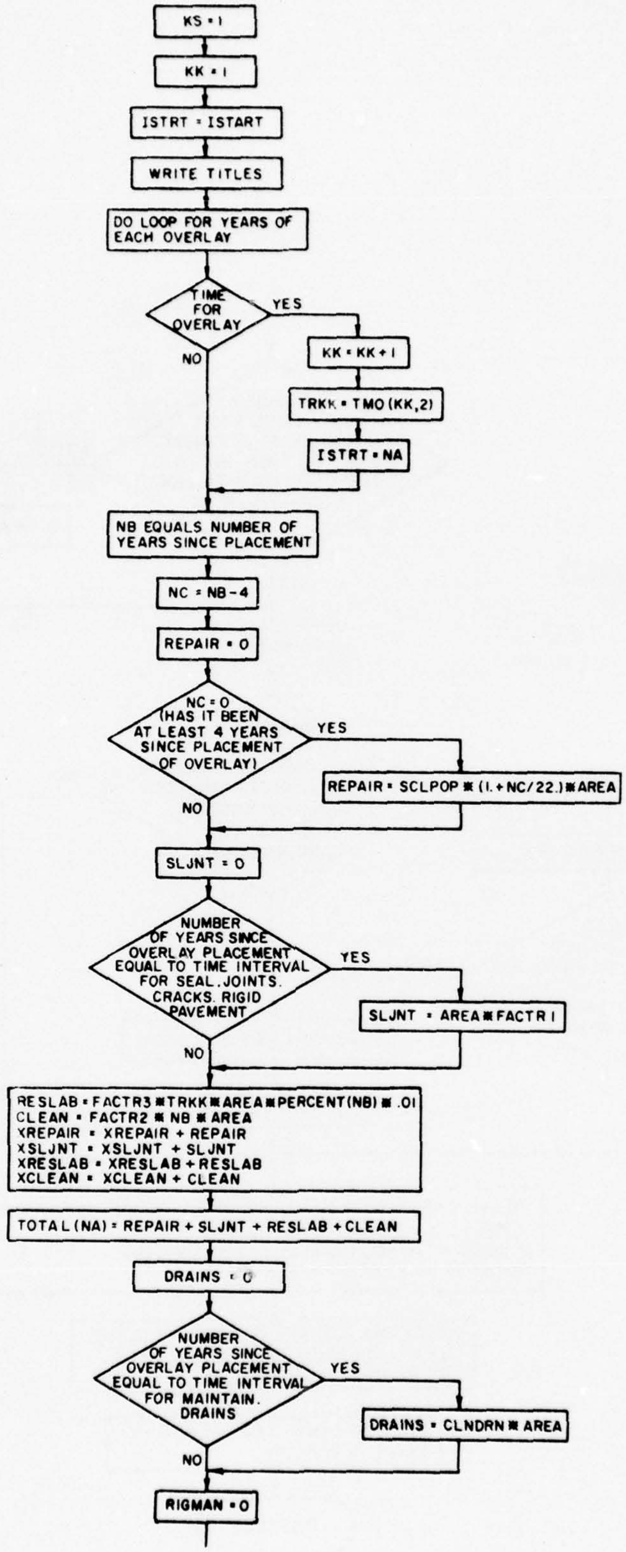


Figure G5. RIGI2 Flowchart.

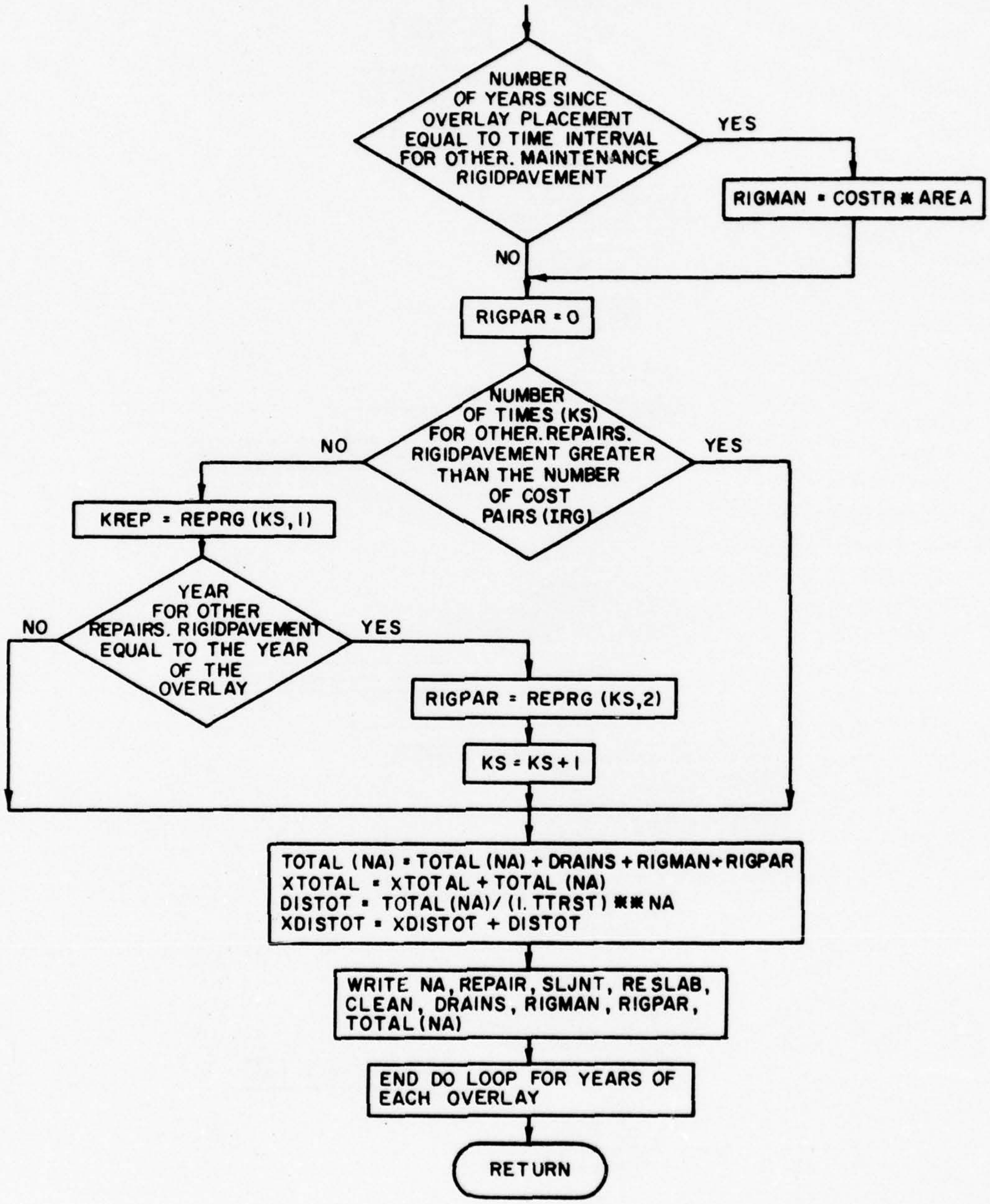


Figure G5. (con't)

APPENDIX H:

SYSTEM ROUTINES

LIFE2 uses various procedures supplied by FORTRAN Extended. These procedures are classified as intrinsic functions, basic external functions, and utility subprograms.* Following is a description of each of the system routines used by LIFE2. Variables in parentheses are the arguments of the routine.

SYSTEM ROUTINE	DESCRIPTION
ABS(X)	Finds the real absolute value of X.[1+]
AINT(X)	Truncates real value X[1].
ALOG(X)	Calculates the natural logarithm of X[2].
ALOG10(X)	Calculates the common logarthm of X[2]
AMIN1(X,Y,...,Z)	Chooses the smallest real value of the argument enclosed in parentheses[1].
COS(X)	Trigonometric cosine of X; X in radians[2].
DATE	Returns current date as month/day/year[3].
EOF(I)	Indicating end-of-file condition on tape I by the index: Zero--no end-of-file encountered; Non-Zero--end-of-file encountered[3].
FLOAT(I)	Converts I from integer to real variable[1].
IABS(I)	Finds the integer absolute value of I[1].
IFIX(X)	Converts X from real to integer value[1].
INT(X)	Same as IFIX; used in truncation[1].

* *FORTRAN Extended Version 4: Reference Manual*, Control Data Corporation.

\+ Footnotes classifying the routines are given at the end of this Appendix.

MOD(I,J)	Remaindering. MOD (I,J) is defined as a-[a/b]b, where X is the largest integer that does not exceed the magnitude of X with a sign the same as X. The results are not defined when the second argument is zero.[1]
OVERLAY(FN,I,J,RECALL,K)	Utility subprogram which loads an overlay where: FN = The variable name of location containing the name of the file in H format. I,J = Overlay level numbers in understood octal. RECALL = Optional recall parameter. K = Optional parameter specifying where the overlay is located; can be zero, non-zero, or 7-character L format Hollrith constant. If the K parameter is zero or not specified, the overlay is included in the file reference by name.[3]
REMARK(H)	Utility subprogram to place a message in the output dayfile. H is a Hollerith field.[3]
SECOND(X)	Returns the control processor time from start-of-job in seconds as a real number.[3]
SHIFT(X,I)	Shifts X, I bit positions; left circular if I is positive.[1]
SIN(X)	Trigonometric sine of X; X in radian[2].
SQRT(X)	Square root of X value[2].
TAN(X)	Trigonometric tangent of X; X in radians[2].

[1] Intrinsic function.
[2] Basic external function.
[3] Utility subprogram.

APPENDIX I:

ERROR MESSAGES

As a convenience to the user, error checks are incorporated into the LIFE2 program to aid in debugging the input cards. However, error check routines are not comprehensive, and the user is therefore cautioned to recheck input for accuracy and completeness.

The error messages incorporated in LIFE2 are listed below according to the routine in which they originate.

MAIN

"WANDER IS CHANNELIZED"
"WANDER IS UNCHANNELIZED"
"WANDER IS UNDEFINED"
"THIS IS A MAINTENANCE PROBLEM"
"THIS IS A LIFE CYCLE PROBLEM"
"PROBLEM TYPE UNDEFINED. A DESIGN PROBLEM IS ASSUMED"
"THIS IS A DESIGN PROBLEM"

COV5K

"COV5K-SUBGRADE MODULUS GREATER THAN 500 OR LESS THAN 25-OFF CHART, XK= " XK

"COV5K-CONCRETE FLEXURAL STRENGTH GREATER THAN 800 OR LESS THAN 500-OFF CHART, FS= " FS

COPY

"VEHICLE", NAME (3),J=1,3, "NOT FOUND IN VEHICLE DATA BANK"

PACKET

"ERROR.MODE=", MODE, "VALUE," VALUE "ENTITY=,"ENTITY(I), I=1,NW

"THE FOLLOWING NAME IS NOT IN THE SCAN DICTIONARY OR WAS IMPROPERLY USED", ENTITY (I), I=1,NW

"DATA DEFINING THE VARIABLE", ALIST (ILOC) or BLIST (FLOC) or CLIST (ILOC), "IS NOT IN THE PROPER MODE"

"PROGRAMMING ERROR. THERE IS NO STATEMENT ASSIGNED FOR", TA(1) or TA(2) or TA(3) V, "LIST (",ILOC,")=", ALIST(ILOC).orBLIST(ILOC) or CLIST(ILOC)

"ERROR.LESS THAN", IVALUE, "ITEMS HAVE BEEN DEFINED FOR THE CORRESPONDING MATERIAL IN THE MATERIAL PROPERTIES TABLE."

"ERROR. 10 STRESSES ARE REQUIRED,",I,"STRESSES WERE READ"

"THE FOLLOWING ENTITY IS OUT OF SEQUENCE", ENTITY1(J),J=1, NW

"ERROR. NO.SUBBASE.SCHEMES =", MLYST, "BUT ONLY", NSGY," WERE ENCOUNTERED"

"THE INPUT ITEM--RANGE.OF.THICKNESS--SHOULD BE FOLLOWED BY TWO PARAMETERS",/,"ONLY ONE PARAMETER WAS ENCOUNTERED. PLEASE CHECK INPUT DATA"

"WARNING. A TOTAL OF", I,"VARIABLES HAVE BEEN SPECIFIED FOR YEARLY TRAFFIC",/,"HOWEVER, THE DESIGN LIFE WAS SPECIFIED TO BE", JDL, "YEARS,"/ " THEREFORE, THE DESIGN LIFE HAS BEEN REDEFINED TO BE", I, "YEARS"

"ERRORS HAVE BEEN ENCOUNTERED. JOB TERMINATED"

<u>CKDATA</u>

ALIST(I) OR BLIST(I) or CLIST (I), "MUST BE READ"

CLIST(I), RLIST(1) or RLIST(2) or RLIST(3) or RLIST(4),
"MUST BE READ"

"REQUIRED VARIABLES"

"THERE ARE", N10, "ERRORS OF OMISSION"

<u>PLABAY</u>

"ERROR. THE FOLLOWING DATA IS IMPROPERLY USED", ENTITY(I), I=1,J

"ERROR FOUND IN FLEXIBLE.PAVEMENT.PROPERTIES TABLE. PLEASE CHECK INPUT DATA"

"ERROR. THE FOLLOWING DATA APPEARS TO BE OUT OF SEQUENCE", ENTITY (I), I=1,J

C TABLE

"THE FOLLOWING NAME IS NOT IN THE SCAN DICTIONARY OR WAS IMPROPERLY USED," ENTITY (I1), I1=1,NW

"ERROR. MORE THAN 8 SEGMENTS HAVE BEEN SPECIFIED."

PARSE

"ALL DATA PROCESSED"

ERN

"ERROR NO.",N1,"PROCEDURE",N2(1),"SUBROUTINE",N2(2),"STATEMENT NO.", N3

PAVE

"PARTIAL PROTECTION IS THE DESIGN CRITERIA THIS ANSWER WAS BASED ON"

"FULL PROTECTION IS THE DESIGN CRITERIA THIS ANSWER WAS BASED ON"

"REDUCED SUBGRADE STRENGTH IS THE DESIGN CRITERIA THIS ANSWER WAS BASED ON"

TLMC

"INADMISSABLE CASE--TLMC(DENSITY CHARTS)-IA,IB,IC,ID,IE,A,TLU,TLL", IA,IB,IC,ID,IE,A,TLU,TLL

TLMM

"INADMISSABLE CASE-TLMM (THICKNESS CHARTS)"

MIXED

"MIXED-THICKNESS ARE IN ERROR, MUST BE LARGER"

SERCST

"STOP FROM SUBROUTINE SERCST-CALL FOR NONEXISTENT COST DATA"

ERROR

"A POINT ON THE TEMPLATE LIES OUTSIDE THE RANGE OF TERRAIN DATA."

"DISPLAY SEGMENT IS OUT OF RANGE OF THE PROFILE GRADE LINE."

"TERRAIN DATA OVERFLOW-ONLY 50 ROWS MAY BE ENTERED-EXECUTION CONTINUING."

"DUPLICATE TERRAIN DATA FOUND."

"TERRAIN DATA OVERFLOW-ONLY 40 POINTS MAY BE CONTAINED IN A SINGLE ROW-EXECUTION CONTINUING."

"APPROACH DATA CARD MISSING TO INPUT--EARTHWORK VALUE CHANGED TO PAVEMENT"

"SYSTEM ERROR-TWO TERRAIN DATA ROWS AT THE SAME POSITION."

"SYSTEM ERROR-DUPLICATE POINTS WITHIN A TERRAIN ROW"

"DUPLICATE POINT WITHIN TEMPLATE OR PROFILE GRADE LINE."

"ELEVATION LIMIT VIOLATION. COMPUTED ELEVATION HAS REACHED HIGHEST LIMIT, ELEVATION HAS BEEN REASSIGNED, EXECUTION CONTINUING."

"ELEVATION LIMIT VIOLATION. COMPUTED ELEVATION HAS REACHED LOWEST LIMIT, ELEVATION HAS BEEN REASSIGNED, EXECUTION CONTINUING."
"LOWEST LIMIT WARNING MESSAGE NOW TERMINATED FINAL COUNT WILL FOLLOW."

"HIGHEST ELEVATION LIMIT"_"TIMES, LOWEST ELEVATION LIMIT REACHED"
REACHED_"TIMES

"EXTRAPOLATION HAS OCCURRED___. ___INDIVIDUAL EXTRAPOLATIONS HAVE OCCURRED IN THIS RUN."

OUTB

"ANALYSIS TERMINATED BECAUSE OF FOLLOWING INPUT ERRORS"

"MISSING DESIGN LOAD"

"INVALID CONFIGURATION CODE."

"INVALID TRAFFIC AREA CODE OR INVALID DESIGN INDEX"

"INCOMPATIBLE FROST CRITERIA GIVEN"

"INVALID PAVEMENT TYPE CODE"

"MISSING PAVEMENT THICKNESS"

"INVALID MINOR CODE"

"INVALID FROST GROUP"

"SUBGRADE MOISTURE MISSING"

"SUBGRADE MODULUS MISSING"

"INVALID HOR. VAR. CODE"

"MISSING BASE MOISTURE CONTENT"

"MISSING BASE DRY UNIT WEIGHT"

"BASE MOISTURE/DRY WEIGHT INCOMPATIBILITY"

"INVALID DRY WEIGHT"

"BASE CBR INCOMPATIBILITY"

"INVALID CBR"

"INCOMPATIBLE CONFIGURATION CODE/TRAFFIC AREA"

"INVALID FLEXIBLE OVERRIDE"

RL

"SINCE THE EXISTING PAVEMENT IS IN A STATE OF COMPLETE.FAILURE, A FLEXIBLE OVERLAY IS NOT CONSIDERED. IT IS SUGGESTED THAT RECONSTRUCTION BE INVESTIGATED--I.E., THAT A LIFE.CYCLE OPTION BE RUN"

APPENDIX J:

VEHICLE DATA BANK

This appendix describes the format and content of the vehicle data bank used by the LIFE2 program to account for the traffic variable. This data bank contains the necessary traffic information for considering roadway pavements as well as airfield pavements.

Input Format*

Thirteen cards are necessary to code the information for each type of vehicle. The first eight cards pertain to rigid pavement design,+ while the last five pertain to flexible pavement design.++ The items contained on each card and the required input format are described below.**

CARD TYPE	ITEM	CARD COLUMN	INPUT FORMAT	DESCRIPTION
A	1	1	A1	Dollar sign ($) required to signify beginning of data for a particular vehicle.
	2	2-31	A12	VEHICLE.TYPE
	3	31-40	A9	RIGID
		41-49	9X	Blank
	4	50-59	F10.5	Pass/coverage ratio for channelized traffic.
	5	60-69	F10.5	Pass/coverage ratio for unchannelized traffic.
		70-76	7X	Blank

* The data bank uses a fixed format.

\+ Further information about these parameters is contained in W. C. Kreger, *Computerized Aircraft Ground Flotation Analysis--Edge Loaded Rigid Pavement*, ERR-FW-572 (General Dynamics Corp., 1967).

++ Card types, J, K, and L contain ESWL data for various pavement thicknesses. The "Calculation of Equivalent Single-Wheel Loads" section discusses the procedure for deriving these data.

** Although the descriptions sometimes use aircraft terminology, they are applicable to roadway vehicles.
Data for C-5A aircraft, if used, should always appear as the last vehicle in the data bank, because of its unsymmetrical landing gear configuration. (See the "Coding of Unsymmetrical Wheel Configurations" section for a discussion of the C-5A data coding.)
The complete vehicle data bank must be followed by a card having a dollar sign ($) in column 1.

	6	77-78	I2	Designates type of gear:01 for tricycle; 02 for bicycle. Specify 01 for road design.
	7	79-80	I2	Designates wheel type:02 for twin-tandem; 00 for all others (including Road Load).
B	1	1-50	A50	VEHICLE.TYPE
C	1	1-10	F10.0	Weight/gear for airfields and weight/axle for roads (lb).
		11-19	8X	
	2	20-30	F10.0	Wheel contact area (sq. in.).
	3	31-40	F5.0	Number of gammas (set equal to 1; i.e., only one year location will be considered in LIFE2--see Figure J1)
D	1	1-10	F10.0	a
	2	11-20	F10.0	b Gear spacing parameters--see Figure J2
	3	21-30	F10.0	c
	4	31-40	F10.0	d
	5	41-50	F10.0	Number of deltas (set equal to 1; i.e., only one gear location will be considered in LIFE2--see Figure J1).
	6	51-60	F10.0	Number of -G pairs; i.e., extra pairs of pavement stress and the correlative gear load to be considered (set equal to 0).
E	1	1-10	F10.0	N_a
	2	11-20	F10.0	N_b Gear spacing parameters*--see Figure J2).
	3	21-30	F10.0	N_c
	4	31-40	F10.0	N_d
	5	41-50	F10.0	e The tire print width/tire print length; greater than 1. (Default value is 1.667 if 0 entered or if left blank.)
F	1	1-10	F10.0	B. This parameter provides control for determining the number of points used to determine the shape of the tire print perimeter. (Set equal to 75.)
G	1	1-10	F10.0	Gamma. A gear location parameter--see Figure J1.

* Unsymmetrical wheel configurations use X-Y coordinates rather than spacing parameters (see Kreger report).

H	1	1-10	F10.0	Delta. A gear location parameter--see Figure J1.
I				Duplicate of card type A, except FLEXIBLE replaces RIGID in columns 31-40.+
J	1-7	1-70	7E10.0	Equivalent single-wheel loads for seven pavement thicknesses.++
K	1-7	1-70	7E10.0	Equivalent single-wheel loads for seven pavement thicknesses.
L	1-6	1-60	6E10.0	Equivalent single-wheel loads for six pavement thicknesses.
M	1	1-10	F10.0	Tire contact area for one wheel (sq in).
	2	11-20	F10.0	Number of wheels used to compute equivalent single-wheel loads.

Calculation of Equivalent Single-Wheel Loads

Card Types J, K, and L of the vehicle data bank contain information required in the flexible pavement design analysis. The information is in the form of an equivalent single-wheel load (ESWL) vs. pavement thickness curve. This curve is generated by calculated ESWLs for 20 pavement thicknesses. The thicknesses used in airfield design are: 1, 2, 3, 4, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, and 150. The thicknesses used in road design are: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 22, 24, 28, 32, and 36.

A Boussinesq solution is used to calculate the equivalent single-wheel loads for the above thicknesses. In the solution, the load required on a single-wheel (with the same contact area as one wheel in the multiple-wheel configuration) which produces a maximum deflection equivalent to that of the multiple-wheel load is determined for each thickness.

+ For twin-tandem wheels, the pass to coverage ratio for flexible pavements is one-half that of rigid pavements; however, in coding these data, the rigid value is used on both Card A and Card I, and the reduction is performed in the program.

++ See "Calculation of Equivalent Single-Wheel Loads" section for description of thicknesses used.

The Boeing Aircraft Transportation Division[1] has developed a computerized procedure for calculating ESWLs. This program has since been modified by the Waterways Experiment Station and adapted to the CDC 6600 computer by the Construction Engineering Research Laboratory. Sample input data for the program are shown in Figure J3. Figure J4 gives the program output for this data analysis. Column 7 of this output provides the pavement thicknesses analyzed in this run. Column 1 provides the calculated ESWL for each thickness. The other columns contain extraneous information. Note that ESWLs can be calculated for only eight depths (i.e., pavement thicknesses), and that these depths increase incrementally in each program run. Thus, the program must be run several times with properly selected depth increments to obtain the required data.

Coding of Unsymmetrical Wheel Configurations

Vehicle data pertaining to rigid pavements are used to calculate bending stresses (CSOG and CSOA). A limitation of this procedure is that the wheel configuration being analyzed must have a double center line of symmetry (such as those shown in Figure J2). However, since the stress equations are linear, this limitation may be eliminated by dividing the wheel configuration into symmetrical portions and summing the solutions.

The C-5A aircraft is the only vehicle having an unsymmetrical wheel configuration presently included in the data bank (see Figure J5). Since this vehicle is prevalent in airfield design traffic, the LIFE2 rigid pavement analysis was modified to accept it. The information necessary for this modification is contained in the data bank:*

1. On card type E, in columns 51-60, the number of tire coordinate pairs is specified. Since the C-5A has six tire coordinate pairs, a 6 is placed within these columns.

2. The tire coordinate pairs are placed on data cards immediately following card type E. The format is (10F6.0) with a maximum of five pairs per data card. Figure J6 illustrates a coordinate system for the C-5A wheel configuration.

3. The C-5A cards must be the last in the vehicle data bank.

---

[1] *Ground Flotation Design*, Document D6-4088 TN (Boeing Aircraft Transport Division, 1969).

* See the data cards for the C-5A as shown in Figure J7.

Vehicle Data Bank Contents

The vehicle data bank presently used with the LIFE2 program contains information about 33 vehicles. This includes information for 32 aircraft and one set of data for road design. Vehicles contained in the data bank are:

Road-Load		
Heavy-Load	C-124C	
Medium-Load	C-130E	KC-97G
Light-Load	C-135A	KC-135A
Special-Load	C-140A	Boeing-707
B-47E	C-141A	Boeing-727
B-52	F-4E	Boeing-747
B-57B	F-104G	DC-8-10
C-7A	F-11A	DC-9-30
C-8A	A-7D	DC-10-10
C-54G	A-26A	Convair-880
C-123K	HC-130H	C-5A

Figure J7 is a computer printout of the vehicle data bank contents. The information, as shown, conforms to the format given in the Data Input Format section.

Additions to Data Bank

The user of the LIFE2 program may need to add information about new or different vehicles to describe the traffic being considered for a specific project. This can be done by using the format given in the "Data Input Format" section. Additional information about deriving the necessary data can be found in documents describing aircraft charateristics.[2]

Use of the Data Bank

The vehicle data bank used with the LIFE2 program can be a multiple file (as presented in the "Vehicle Data Bank Contents" section) or a singular file for an individual project.

---

[2] DeLynn R. Hay, *Aircraft Characteristics for Airfield Pavement Design and Evaluation*, Technical Report No. AFWL-TR-69-54 (Air Force Weapons Laboratory, October 1969) and *Pertinent Characteristics of Military Aircraft*, Miscellaneous Paper No. 5-1 (Ohio River Division Laboratories, July 1964).

The multiple file would contain data about vehicles which could be required as design traffic. This file can be retained on a computer disc file. The entire file would then be called by LIFE2 and searched for the required vehicle types.

The singular file would be developed for a specific project. It would contain only the vehicles being considered as design traffic for a specific problem. The data (coded as in the "Data Input Format" section) should be placed on computer cards and input after the LIFE2 control cards.

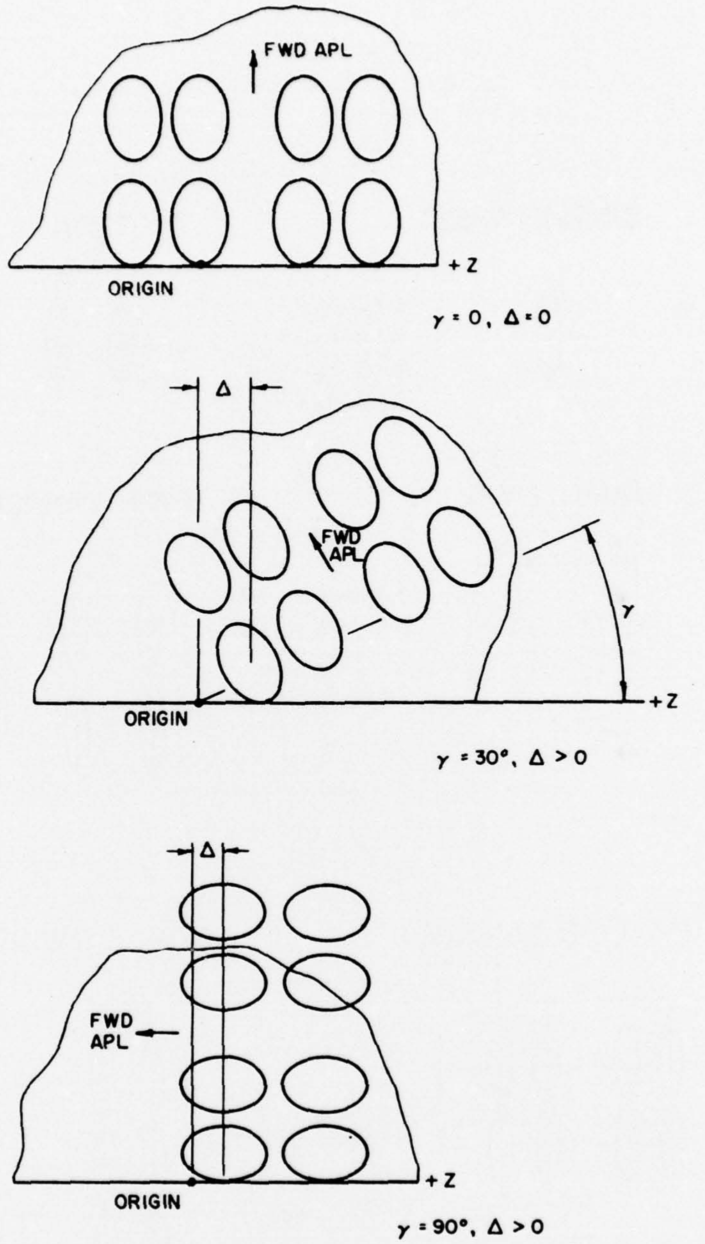


Figure J1. Description of gamma and delta parameters. (from W. C. Kreger, *Computerized Aircraft Ground Flotation Analysis--Edge-Loaded Rigid Pavement*, ERR-FW-572 General Dynamics Corp., 1967.)

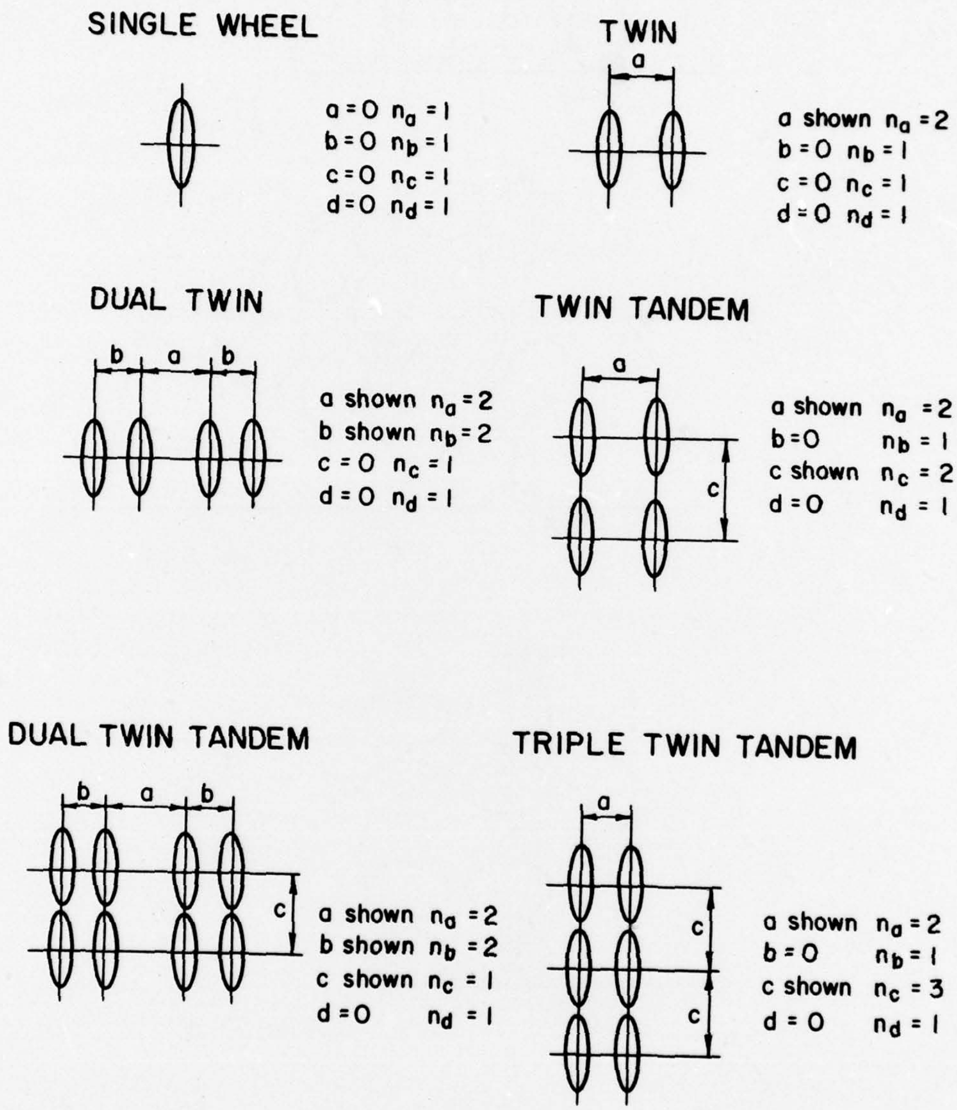


Figure J2. Wheel configuration spacing parameters. (from W. C. Kreger, *Computerized Aircraft Ground Flotation Analysis--Edge-Loaded Rigid Pavement*, ERR-FW-572 [General Dynamics Corp., 1967].)

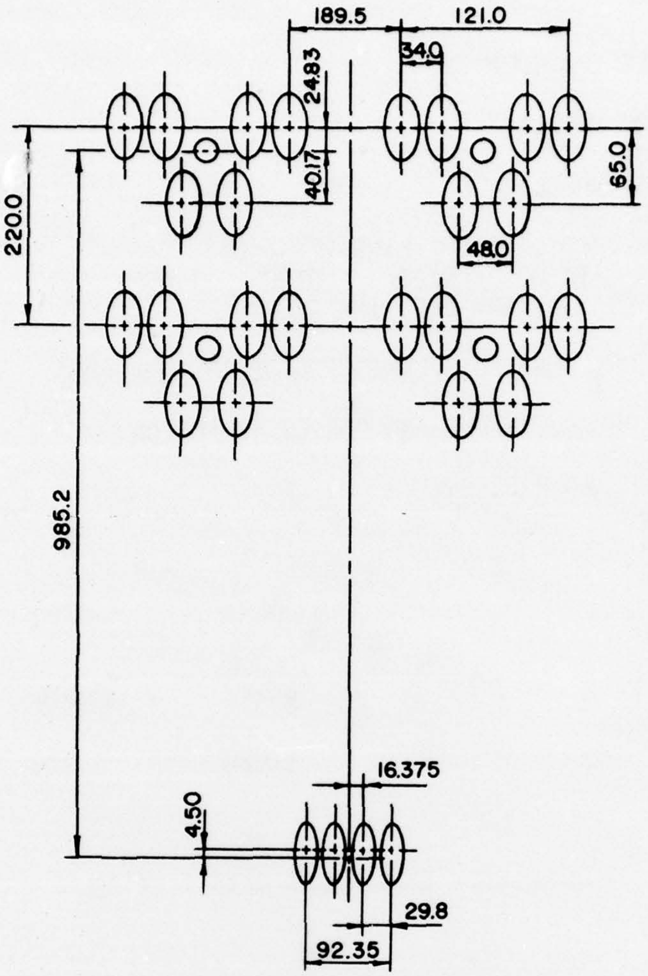
```
NUMBER OF WHEELS (MAXIMUM 32)
      2
X COORDINATES OF WHEELS
   0.00   13.50
Y COORDINATES OF WHEELS
   0.00    0.00
LOC. OF GRD,GRD INCRT, NO. OF LINS (MAX(10))
   0.00      .75   10.00    0.00     0.00    1.00
NUMBER OF DEP. (MAX08) AND DEP. INCREMENT
   6.00    5.00
DESIRED NO. OF ORD. MAX. DISPLCMTS PER DEPTH (MAX.=06)
      2
NO. OF SETS OF PRESS., RAD., AND PASSES TO FOLLOW
      1
REFERENCE RADIUS AND PRESSURE
   4.52   70.00
PRESSURES
  70.00   70.00
RADII
   4.52    4.52
PASSES
     1174      5114        22348        98485        435606
ALPHA VALUES MAX(5)
     .764      .860         .940        1.020         1.100
CONTACT AREA
    64.29
```

Figure J3. ESWL input data listing.

ESWL POUNDS	CBR PASSES 1174	CBR PASSES 5114	CBR PASSES 22348	CBR PASSES 98485	CBR PASSES 435606	-T- DEPTH IN.
5283.	109.3	109.3	109.3	109.3	109.3	0.0
5746.	11.1	13.0	14.4	15.8	17.2	5.0
6761.	4.3	5.3	6.2	7.2	8.2	10.0
7679.	2.3	2.9	3.4	4.0	4.6	15.0
8159.	1.4	1.8	2.1	2.5	2.9	20.0
8427.	1.0	1.2	1.4	1.7	1.9	25.0

ZERO CBR VALUES IMPLY NO COMPUTATION WAS POSSIBLE

Figure J4. ESWL program results.



MAIN LANDING GEAR CONFIGURATION-TWIN DELTA TANDEM
NOSE LANDING GEAR-TWIN-TWIN

Figure J5. C-5A landing gear configuration.

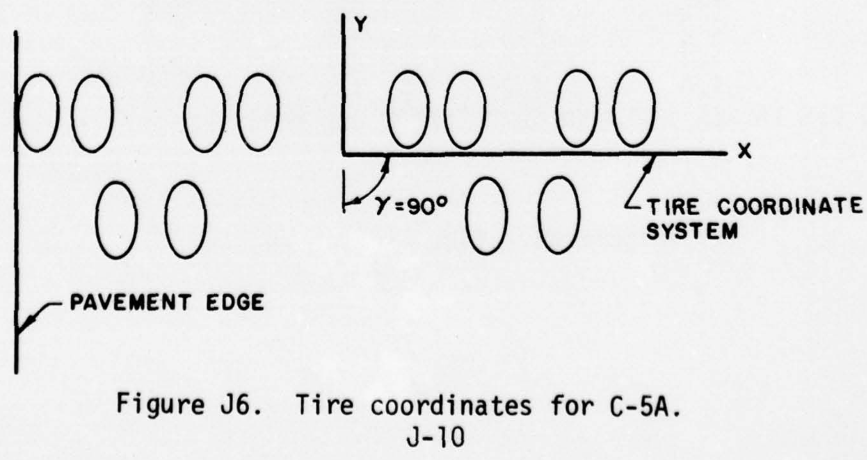


Figure J6. Tire coordinates for C-5A.

```
                    VEHICLE DATA BANK    AS OF   01 JANUARY 1978

$ROAD-LOAD                            RIGID               1.0       1.0                 0100
          ROAD-LOAD
30000.               54.0      1.0
58.5      . 13.5     0.0       0.0       1.0       0.0
2.0       2.0        1.0       1.0
75.
90.0
0.0
$ROAD-LOAD                            FLEXIBLE            1.0       1.0                 0100
5303.E0   5363.E0    5462.E0   5592.E0   5746.E0   5916.E0   6112.E0
6317.E0   6534.E0    6761.E0   7679.E0   8159.E0   8427.E0   8588.E0
8761.E0   8846.E0    8893.E0   8922.E0   8941.E0   8954.E0
64.29     2.

$HEAVY-LOAD                           RIGID               1.68      2.0                 0200
          HEAVY-LOAD
265000.0             267.0     1.0
62.0      37.0       0.0       0.0       1.0       0.0
2.0       2.0        1.0       1.0
75.
90.0
0.0
$HEAVY-LOAD                           FLEXIBLE            1.68      2.0                 0200
94887.E0  95229.E0   95786.E0  96544.E0  97486.E0  104290.E0 113290.E0
123367.E0 133860.E0 145083.E0 165064.E0 182058.E0 197360.E0 211688.E0
225069.E0 236172.E0 245321.E0 259217.E0 268982.E0 272777.E0
267.      4.

$MEDIUM-LOAD                          RIGID               3.14      5.62                0100
          MEDIUM-LOAD
100000.              267.      1.
37.       0.         0.        0.        1.        0.
2.        1.         1.        1.
75.
90.
0.
$MEDIUM-LOAD                          FLEXIBLE            3.14      5.62                0100
112405.E0 112638.E0 113019.E0 113538.E0 114185.E0 118887.E0 125143.E0
132721.E0 142152.E0 151397.E0 167364.E0 176988.E0 183024.E0 186997.E0
189727.E0 191674.E0 193105.E0 195022.E0 196207.E0 196636.E0
267.      2.

$LIGHT-LOAD                           RIGID               8.58      17.0                0100
          LIGHT-LOAD
25000.               100.      1.
0.        0.         0.        0.        1.        0.
1.        1.         1.        1.
75.
90.
0.
$LIGHT-LOAD                           FLEXIBLE            8.58      17.0                0100
25000.E0  25000.E0   25000.E0  25000.E0  25000.E0  25000.E0  25000.E0
25000.E0  25000.E0   25000.E0  25000.E0  25000.E0  25000.E0  25000.E0
25000.E0  25000.E0   25000.E0  25000.E0  25000.E0  25000.E0
100.      1.

$SPECIAL-LOAD                         RIGID               4.92      9.80                0100
          SPECIAL-LOAD
53000.               241.      1.
```

Figure J7. Vehicle data bank contents--September 1977.

```
0.          0.          0.          0.          1.
1.          1.          1.          1.
75.
90.
0.
$SPECIAL-LOAD                       FLEXIBLE                4.92        9.80                0100
53000.E0    53000.E0    53000.E0    53000.E0    53000.E0    53000.E0    53000.E0
53000.E0    53000.E0    53000.E0    53000.E0    53000.E0    53000.E0    53000.E0
53000.E0    53000.E0    53000.E0    53000.E0    53000.E0    53000.E0
241.        1.

$B-47E                              RIGID                   1.57        2.81                0200
      B-47E
129000.                 280.        1.
37.         0.          0.          0.          1.          0.
2.          1.          1.          1.
75.
90.
.0
$B-47E                              FLEXIBLE                1.57        2.81                0200
36361.E0    36435.E0    36556.E0    36720.E0    36925.E0    38424.E0    40429.E0
43023.E0    45889.E0    48889.E0    53940.E0    57006.E0    58950.E0    60239.E0
61130.E0    61767.E0    62238.E0    62869.E0    63261.E0    63403.E0
280.          2.

$B-52                               RIGID                   1.68        2.0                 0200
            B-52
265000.0                267.0       1.0
62.0        37.0        0.0         0.0         1.0         0.0
2.0         2.0         1.0         1.0
75.
90.0
0.0
$B-52                               FLEXIBLE                1.68        2.0                 0200
94887.E0    95228.E0    95786.E0    96544.E0    97486.E0    104290.E0 113290.E0
123367.E0 133860.E0 145083.E0 165064.E0 182058.E0 197360.E0 211688.E0
225069.E0 236172.E0 245321.E0 259217.E0 268982.E0 272777.E0
267.        4.

$B-57B                              RIGID                   6.47        12.83               0100
          B-57B
27500.                  182.        1.
0.          0.          0.          0.          1.
1.          1.          1.          1.
75.
90.
0.
$B-57B                              FLEXIBLE                6.47        12.83               0100
27500.E0    27500.E0    27500.E0    27500.E0    27500.E0    27500.E0    27500.E0
27500.E0    27500.E0    27500.E0    27500.E0    27500.E0    27500.E0    27500.E0
27500.E0    27500.E0    27500.E0    27500.E0    27500.E0    27500.E0
182.        1.

$C-7A                               RIGID                   2.78        5.42                0100
            C-7A
12500.                  152.        1.
20.         0.          0.          0.          1.
2.          1.          1.          1.
75.
90.
0.
$C-7A                               FLEXIBLE                2.78        5.42                0100
7154.E0     7191.E0     7251.E0     7331.E0     7429.E0     8200.E0     9191.E0
10077.E0     10648.E0     11023.E0     11459.E0     11689.E0     11817.E0     11899.E0
11954.E0    11992.E0    12020.E0    12056.E0    12078.E0    12086.E0
152.        2.
```

Figure J7. (con't)

```
$C-8A                                   RIGID              3.16      6.10               0100
          C-8A
17500.               218.      1.
23.       0.         0.        0.        1.
2.        1.         1.        1.
75.
90.
0.
$C-8A                                   FLEXIBLE           3.16      6.10               0100
9822.E0   9860.E0    9921.E0   10003.E0  10106.E0  10945.E0  12051.E0
13237.E0  14094.E0   14663.E0  15392.E0  155775.E0  16000.E0  16143.E0
16238.E0  16305.E0   16354.E0  16418.E0  16457.E0  16471.E0
218.      2.

$C-54G                                  RIGID              3.05      5.75               0100
          C-54G
38500.               250.      1.
29.       0.         0.        0.        1.
2.        1.         1.        1.
75.
90.
0.
$C-54G                                  FLEXIBLE           3.05      5.75               0100
22244.E0  22326.E0   22427.E0  22564.E0  22734.E0  23965.E0  25887.E0
27997.E0  30261.E0   32045.E0  34325.E0  35623.E0  36413.E0  36924.E0
37270.E0  37515.E0   37694.E0  37932.E0  38079.E0  38131.E0
250.      2.

$C-123K                                 RIGID              5.23      10.38              0100
          C-123K
25300.               275.      1.
0.        0.         0.        0.        1.
1.        1.         1.        1.
75.
90.
0.
$C-123K                                 FLEXIBLE           5.23      10.38              0100
25300.E0  25300.E0   25300.E0  25300.E0  25300.E0  25300.E0  25300.E0
25300.E0  25300.E0   25300.E0  25300.E0  25300.E0  25300.E0  25300.E0
25300.E0  25300.E0   25300.E0  25300.E0  25300.E0  25300.E0
275.      1.

$C-124C                                 RIGID              2.19      3.77               0100
          C-124C
50500.               640.      1.
44.       0.         0.        0.        1.
2.        1.         1.        1.
75.
90.
0.
$C-124C                                 FLEXIBLE           2.19      3.77               0100
58302.E0  58360.E0   58459.E0  58599.E0  58784.E0  60373.E0  62846.E0
65792.E0  69176.E0   72843.E0  79795.E0  84732.E0  88218.E0  90717.E0
92543.E0  93905.E0   94942.E0  96381.E0  97301.E0  97640.E0
640.      2.

$C-130E                                 RIGID              4.36      8.72               0100
          C-130E
83700.               440.      1.
0.        0.         60.       0.        1.        0.
1.        1.         2.        1.
75.
90.
0.
$C-130E                                 FLEXIBLE           4.36      8.72               0100
```

Figure J7. (con't)

```
45921.E0  45967.E0  46042.E0  46146.E0  46276.E0  47259.E0  48637.E0
50257.E0  52027.E0  54086.E0  58576.E0  63413.E0  67974.E0  71282.E0
73643.E0  75486.E0  76847.E0  78728.E0  79927.E0  80368.E0
440.      2.

$C-135A                       RIGID               3.36      6.06              0100
          C-135A
131900.             230.      1.
36.       0.        60.       0.        1.
2.        1.        2.        1.
75.
90.
0.
$C-135A                       FLEXIBLE            3.36      6.06              0100
131900.E0 131900.E0 131900.E0 131900.E0 131900.E0 131900.E0 131900.E0
131900.E0 131900.E0 131900.E0 131900.E0 131900.E0 131900.E0 131900.E0
131900.E0 131900.E0 131900.E0 131900.E0 131900.E0 131900.E0
230.      1.

$C-140A                       RIGID               6.85      12.89             0100
          C-140A
17500.              43.       1.
14.5      0.        0.        0.        1.
2.        1.        1.        1.
75.
90.
0.
$C-140A                       FLEXIBLE            6.85      12.89             0100
9995.E0   10119.E0  10307.E0  10543.E0  10814.E0  12657.E0  14585.E0
15683.E0  16299.E0  16670.E0  17069.E0  17265.E0  17375.E0  17442.E0
17486.E0  17517.E0  17539.E0  17568.E0  17585.E0  17591.E0
43.       2.

$C-141A                       RIGID               3.44      6.38              0102
          C-141A
14900.              208.      1.
32.5      0.        48.       0.        1.        0.
2.        1.        2.        1.
75.
90.
0.
$C-141A                       FLEXIBLE            3.44      6.38              0102
47977.E0  48222.E0  48620.E0  49159.E0  49921.E0  54507.E0  60850.E0
68411.E0  77296.E0  86174.E0  101875.E0 113752.E0 122058.E0 127953.E0
132227.E0 135395.E0 137793.E0 141100.E0 143202.E0 143974.E0
208.      4.

$F-4E                         RIGID               8.58      17.               0100
          F-4E
27000.              102.      1.
0.        0.        0.        0.        1.        0.
1.        1.        1.        1.
75.
90.
0.
$F-4E                         FLEXIBLE            8.58      17.               0100
27000.E0  27000.E0  27000.E0  27000.E0  27000.E0  27000.E0  27000.E0
27000.E0  27000.E0  27000.E0  27000.E0  27000.E0  27000.E0  27000.E0
27000.E0  27000.E0  27000.E0  27000.E0  27000.E0  27000.E0
102.      1.

$F-104G                       RIGID               11.10     22.0              0100
          F-104G
13500.              63.       1.
0.        0.        0.        0.        1.
1.        1.        1.        1.
```

Figure J7. (con't)

```
75.
90.
0.
$F-104G                                 FLEXIBLE                11.10      22.0                  0100
13500.E0   13500.E0   13500.E0   13500.E0   13500.E0   13500.E0   13500.E0
13500.E0   13500.E0   13500.E0   13500.E0   13500.E0   13500.E0   13500.E0
13500.E0   13500.E0   13500.E0   13500.E0
63.        1.

$F-111A                                 RIGID                   4.92       9.80                  0100
           F-111A
53000.                241.       1.
0.         0.         0.         0.         1.
1.         1.         1.         1.
75.
90.
0.
$F-111A                                 FLEXIBLE                4.92       9.80                  0100
53000.E0   53000.E0   53000.E0   53000.E0   53000.E0   53000.E0   53000.E0
53000.E0   53000.E0   53000.E0   53000.E0   53000.E0   53000.E0   53000.E0
53000.E0   53000.E0   53000.E0   53000.E0   53000.E0   53000.E0
241.       1.

$A-7D                                   RIGID                   11.10      22.0                  0100
           A-7D
17500.                62.        1.
0.         0.         0.         0.         1.
1.         1.         1.         1.
75.
90.
0.
$A-7D                                   FLEXIBLE                11.10      22.0                  0100
17500.E0   17500.E0   17500.E0   17500.E0   17500.E0   17500.E0   17500.E0
17500.E0   17500.E0   17500.E0   17500.E0   17500.E0   17500.E0   17500.E0
17500.E0   17500.E0   17500.E0   17500.E0   17500.E0   17500.E0
62.        1.

$A-26A                                  RIGID                   5.37       10.70                 0100
           A-26A
18500.                262.       1.
0.         0.         0.         0.         1.
1.         1.         1.         1.
75.
90.
0.
$A-26A                                  FLEXIBLE                5.37       10.70                 0100
18500.E0   18500.E0   18500.E0   18500.E0   18500.E0   18500.E0   18500.E0
18500.E0   18500.E0   18500.E0   18500.E0   18500.E0   18500.E0   15500.E0
18500.E0   18500.E0   18500.E0   18500.E0   18500.E0   18500.E0
262.       1.

$HC-130H                                RIGID                   4.58       9.14                  0100
           HC-130H
83700.                364.       1.
0.         0.         60.        0.         1.
1.         1.         2.         1.
75.
90.
0.
$HC-130H                                FLEXIBLE                4.58       9.14                  0100
83700.E0   83700.E0   83700.E0   83700.E0   83700.E0   83700.E0   83700.E0
83700.E0   83700.E0   83700.E0   83700.E0   83700.E0   83700.E0   83700.E0
83700.E0   83700.E0   83700.E0   83700.E0   83700.E0   83700.E0
364.       1.

$KC-97G                                 RIGID                   3.41       6.11                  0100
```

Figure J7. (con't)

```
          KC-97G
88800.                   247.        1.
37.5       0.            0.          0.         1.
2.         1.            1.          1.
75.
90.
0.
$KC-97G                              FLEXIBLE               3.41       6.11                 0100
49760.E0   49887.E0   50062.E0   503[illegible].E0   50595.E0   52725.E0   55568.E0
59261.E0   63099.E0   67208.E0   73945.E0   78154.E0   80879.E0   82711.E0
83991.E0   84915.E0   85600.E0   86525.E0   87102.E0   87312.E0
247.       2.

$KC-135A                             RIGID                  3.36       6.06                 0102
          KC-135A
142000.                  230.        1.
36.        0.            60.         0.         1.          0.
2.         1.            2.          1.
75.
90.
 0.
$KC-135A                             FLEXIBLE               3.36       6.06                 0102
44339.E0   44529.E0   44838.E0   45256.E0   45773.E0   49435.E0   54189.E0
60129.E0   66660.E0   73772.E0   86740.E0   98094.E0   107520.E0 114452.E0
119626.E0 123526.E0 126520.E0 130708.E0 133406.E0 134403.E0
230.       4.

$BOEING-707                          RIGID                  3.24       6.0                  0102
          BOEING-707
120564.0                177.3        1.0
 34.0       0.0          56.0        0.0        1.0         0.0
2.0        2.0           2.0         1.0
75.
90.
0.0
$BOEING-707                          FLEXIBLE               3.24       6.0                  0102
177.3      4.
37177.E0   37363.E0   37662.E0   38064.E0   38556.E0   41963.E0   46283.E0
51494.E0   57209.E0   63809.E0   75645.E0   85872.E0   93693.E0   99347.E0
103511.E0 106628.E0 109005.E0 112305.E0 114416.E0 115194.E0
177.3      4.

$BOEING-727                          RIGID                  3.25       6.00                 0100
      BOEING-727
80000.                   237.        1.
34.        0.            0.          0.          1.
       2.          1.          1.          1.
75.
90.
0.
$BOEING-727                          FLEXIBLE               3.25       6.00                 0100
45029.E0   45136.E0   45312.E0   45551.E0   45847.E0   47979.E0   50970.E0
54561.E0   58425.E0   62537.E0   68447.E0   71891.E0   74016.E0   75399.E0
76343.E0   77012.E0   77503.E0   78157.E0   78561.E0   78706.E0
237.       2.

$BOEING-747                          RIGID                  3.70       5.16                 0102
          BOEING-747
338000.                  207.5       1.0
106.0      44.0          58.0        0.0        1.0         0.0
2.0        2.0           2.0         1.0
75.
90.
0.0
$BOEING-747                          FLEXIBLE               3.70       5.16                 0102
63166.E0   63632.E0   64388.E0   65407.E0   66657.E0   75378.E0   86460.E0
```

Figure J7. (con't)

```
98698.E0  111930.E0 126165.E0 155234.E0 183357.E0 209052.E0 232337.E0
253767.E0 273810.E0 292896.E0 323316.E0 360004.E0 374702.E0
207.5     16.

$DC-8-10                              RIGID             3.14      5.92            0102
       DC-8-10
132150.             228.      1.
30.       0.        55.       0.
2.        1.        2.        1.
75.
90.
0.
$DC-8-10                              FLEXIBLE          3.14      5.92            0102
43767.E0  43978.E0  44321.E0  44747.E0  45362.E0  49464.E0  54999.E0
61880.E0  69530.E0  76692.E0  88847.E0  99254.E0  106903.E0 112566.E0
116817.E0 120056.E0 122563.E0 126103.E0 128408.E0 129265.E0
228.      4.

$DC-9-30                              RIGID             3.58      6.90            0100
       DC-9-30
51300.              165.      1.
26.       0.        0.        0.        1.
2.        1.        1.        1.
75.
90.
0.
$DC-9-30                              FLEXIBLE          3.58      6.90            0100
30655.E0  30770.E0  30956.E0  31206.E0  31513.E0  33740.E0  36734.E0
40205.E0  43566.E0  45947.E0  48836.E0  50406.E0  51335.E0  51924.E0
52319.E0  52596.E0  52797.E0  53063.E0  53225.E0  53283.E0
165.      2.

$DC-10-10                             RIGID             3.64      5.80            0102
       DC-10-10
204250.             295.      1.
54.       0.        64.       0.        1.
2.        1.        2.        1.
75.
90.
0.
$DC-10-10                             FLEXIBLE          3.64      5.80            0102
62524.E0  62709.E0  63011.E0  63423.E0  63935.E0  67660.E0  72636.E0
78317.E0  84675.E0  92289.E0  104492.E0 126379.E0 141415.E0 153054.E0
162050.E0 169046.E0 174540.E0 182412.E0 187605.E0 189549.E0
295.      4.

$CONVAIR-880                          RIGID             3.68      7.16            0100
       CONVAIR-880
87400.              122.      1.
21.5      0.        45.       0.        1.
2.        1.        2.        1.
75.
90.
0.
$CONVAIR-880                          FLEXIBLE          3.68      7.16            0100
28142.E0  28385.E0  28773.E0  29289.E0  29910.E0  34038.E0  39873.E0
45877.E0  51408.E0  56064.E0  64606.E0  70984.E0  75206.E0  78084.E0
80110.E0  81579.E0  82673.E0  84156.E0  85083.E0  85420.E0
122.      4.

$C-5A                                 RIGID             1.62      2.18            0102
       C-5A
181200.             285.      1.
 0.       0.        0.        0.        1.        0.
 0.       0.        0.        0.        0.        6.
60.5  32.5  26.5  32.5  -26.5 32.5  -60.5 32.5  24.0  -32.5
-24.0 -32.5
75.       0.        0.        0.        0.
90.
0.
$C-5A                                 FLEXIBLE          1.62    . 2.18            0102
42859.E0  43074.E0  43426.E0  43905.E0  44501.E0  48834.E0  54594.E0
61062.E0  67823.E0  74623.E0  88184.E0  101770.E0 114416.E0 124892.E0
133424.E0 140474.E0 146129.E0 154662.E0 160557.E0 162824.E0
285.      6.
$
```

Figure J7. (cont')

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